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THE REPORT ON THE DESIGNATION OF NOISE IN ONTARIO

VOLUME III - Appendices J-P

OCCUPATIONAL HEALTH
AND SAFETY DIVISION

MINISTRY OF LABOUR

November, 1982

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THE REPORT ON THE DESIGNATION OF NOISE IN ONTARIO

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APPENDIX Ja

PROPOSED REGULATION UNDER THE OCCUPATIONAL HEALTH AND SAFETY ACT

NOISE - DESIGNATED SUBSTANCE

MINISTRY OF LABOUR
OCCUPATIONAL HEALTH AND SAFETY DIVISION

June 24, 1981

NOISE - DESIGNATED SUBSTANCE

1. In this Regulation,

   (a) noise" means an acoustical signal greater than 80 dB(A).

   (b) "decibel" or "dB" means a unit of measurement for sound pressure level.

   (c) "sound pressure level" ("spl") when measured in units of dB means 20 times the logarithm to the base 10 of the ratio of the root mean square ("rms") pressure of a sound to the root mean square of the reference pressure using a reference of 20 micropascals.

   (d) "decibels A-weighted" or "dB(A)" means a unit of measurement of spl corrected to the A-weighted scale.

   (e) "impulse noise" and "impact noise" mean an impulsive sound caused by collision of solids or sudden change in gases, either as a single pressure pulse or a single burst (multiple pressure pulses) having a duration less than one second with an interval between pulses greater than one second.

   (f) "equivalent continuous sound level" ("Leq") means that sound level in dB(A) which, if present for 40 hours in 1 week, would contain the same total acoustic energy as the various measured sound levels over 1 week.

2. Noise is prescribed as a designated substance.

3. (1) Subject to subsection 2, this Regulation applies to every employer at a work place where a worker is likely to be exposed to noise.

(2) This Regulation does not apply to a constructor or to an employer on a construction project in respect of those workers who work at or on the project.

4. (1) Subject to subsections 2 and 3, every employer shall take all necessary measures and procedures by means of engineering controls, work practice controls and hygiene practices and facilities to ensure that the exposure of a worker to noise does not exceed the equivalent continuous sound level (Leq) of 90 dB(A) for a 40-hour work week as determined in accordance with the International Organization for Standardization (ISO) Reference No. 1999-1975(E).

(2) Every employer shall take all necessary measures and procedures by means of engineering controls and work practice controls to ensure that the exposure of a worker to noise which is not impulse or impact at no time exceeds 115 dB(A).

(3) Every employer shall take all necessary measures and procedures by means of engineering controls and work practice controls to ensure that the exposure of a worker to impulse or impact noise does not exceed the peak sound pressure level measured in units of dB set forth in column 1 of the following table for the maximum number of impulses set out thereto in column 2:

Column 1 Peak Sound Pressure Level dB	Column 2 Maximum Number of Impulses per 8 hour day
115	10,000
125	1,000
135	100
greater than 135	0

(4) Where an employer can prove that all steps reasonable in the circumstances have been taken to require a worker to work in compliance with necessary measures and procedures that are work practice controls as prescribed by subsection 1, the employer does not contravene subsection 1 in respect of a worker who fails to work in compliance therewith.

5. (1) Every employer shall ensure compliance with section 4 without requiring a worker to use hearing protection equipment except,

(a) where the engineering controls and work practice controls required to control the exposure of a worker to noise,

(i) do not exist or are not available,

(ii) are not reasonable or are not practicable for the length of time or frequency of exposure or the nature of the process, operation or work, or,

(iii) are not effective because of a temporary breakdown of equipment, or

(b) in an emergency.

(2) Where hearing protection equipment is provided by an employer and used by a worker the hearing protection equipment shall be appropriate in the circumstances for the type and the sound levels of noise to which a worker is exposed and shall meet, or exceed, the requirements set out in the Code for Hearing Protection dated the 23rd day of June, 1981, and issued by the Ministry.

(3) The employer shall provide training and instruction to a worker in the proper care and use of hearing protection equipment provided by the employer.

6. Where a worker is exposed to a noise level of 85 dB(A) or greater and requests hearing protection equipment the employer shall provide such equipment.

7. (1) Every employer shall cause an assessment to be made, in writing, of the exposure or likelihood of exposure in a work place of a worker to noise.

(2) In causing the assessment to be made, the employer shall take into account such matters as:

(a) the noise level;

(b) the extent and potential extent of the exposure of a worker to noise; and,

(c) the measures and procedures necessary to control such exposure by means of engineering controls and work practice controls.

(3) In causing the assessment to be made, the employer shall consult thereon with the joint health and safety committee or the committee of like nature or the workers or their representatives who participate in an arrangement, program or system conforming to subsection 2 of section 8 of the Act as the case may be, and the committee or the workers or their representatives may make recommendations with respect to the assessessment.

(4) A copy of the assessment made by an employer shall be given by the employer to each member of the joint health and safety committee, or committee of like nature or to the workers or their representatives participating in an arrangement, program or system conforming to subsection 2 of section 8 of the Act.

8. (1) Where the assessment discloses that a worker is likely to be exposed to noise in excess of 85 dB(A) and the health of the worker may be affected thereby, and in any event over 20 hours in a work week, the employer shall put into effect and maintain measures and procedures to control the exposure of the worker to noise and shall incorporate the same into a hearing conservation program.

(2) The hearing conservation program shall include provisions for,

(a) engineering controls, work practice controls, hygiene practices and facilities, and hearing protection equipment as required by sections 4 and 5;

(b) methods and procedures to monitor the exposure of the worker;

(c) maintenance by the employer of personal records of the exposure of the worker;

(d) medical examinations and clinical tests of the exposed worker; and

(e) maintenance by the physician who has examined the worker, or under whose direction the clinical tests have been performed, of records of medical examinations and clinical tests.

(3) In developing the measures and procedures mentioned in subsection 1 and the hearing conservation program, the

employer shall consult with the joint health and safety committee, the committee of like nature or the workers or their representatives, mentioned in subsection 3 of section 7, who may make recommendations with respect to the same.

9. Where a change is made in a process, or in the methods and procedures, and the change could result in a significant difference in the noise level, the employer shall cause a further assessment to be made forthwith and the provisions of sections 7 and 8 shall apply.

10. (1) Where disputes arise between an employer and a joint health and safety committee, a committee of like nature or the workers or their representatives who participate in an arrangement, program or system conforming to subsection 2 of section 8 of the Act as to an assessment required under section 7 or 9 or as to the measures and procedures mentioned in subsection 1 of section 8 or the hearing conservation program or its provisions required under section 8 or 9, the employer, a member of the joint health and safety committee or the committee of like nature or the workers or their representatives may notify an inspector thereof who shall investigate and give a decision in writing to the employer, the committee, or the workers or their representatives.

(2) Nothing in subsection 1 applies to affect the power of an inspector to issue an order for a contravention of any section of this Regulation.

11. (1) A copy of the hearing conservation program put into effect by the employer shall be given by the employer to each member of the joint health and safety committee or committee of like

nature and to the workers or their representatives participating in an arrangement, program or system conforming to subsection 2 of section 8 of the Act and the employer shall acquaint every worker affected by the hearing conservation program with its provisions.

(2) The hearing conservation program put into effect by the employer shall be made available by the employer in English and in the majority language of the work place.

12. Subject to section 18, the procedure for monitoring, and determining, the noise level in a work place and the exposure of a worker thereto, shall be those set out in the Code for Noise Measurement dated the 23rd day of June, 1981 and issued by the Ministry.

13. The results of monitoring of noise in the work place and the exposure of a worker thereto shall be,

(a) posted forthwith by the employer, as soon as the results are available, in a conspicuous place or places at the work place where they are most likely to come to the attention of the workers affected thereby for a period of at least fourteen days;

(b) furnished to the joint health and safety committee, committee of like nature or the workers or their representatives who participate in an arrangement, plan or program mentioned in subsection 3 of section 7; and

(c) kept by the employer for a period of at least five years.

14. (1) A worker shall undergo the medical examinations and clinical tests as the hearing conservation program provides at the expense of the employer.

(2) The medical examinations and clinical tests required to be provided in a hearing conservation program shall make provisions for:

(a) pre-employment and pre-placement medical examinations to include

(i) a medical history,

(ii) an otoscopic examination,

(iii) audiometric tests, and

(b) periodic medical examinations and audiometric tests consisting of the items prescribed in clause a.

(3) Subject to section 18, the audiometric tests of a worker shall be determined in accordance with the Code for Audiometry dated the 23rd day of June, 1981 and issued by the Ministry.

(4) The medical history and otoscopic examination shall meet the provisions of the Code for Medical Surveillance for Noise dated the 23rd day of June, 1981 and issued by the Ministry.

15. (1) The records of the exposures of each worker to noise at the work place to be maintained under the hearing conservation program shall identify the worker, including his date of birth, his jobs or occupations at the work place, the results of monitoring for his exposure to noise in his work area and the use by the worker of hearing protection equipment and its type.

(2) The employer shall provide a copy of the records of the exposures of the worker to noise to the physician who examines

the worker and under whose supervision the clinical tests of the worker are performed.

16. (1) The records of medical examinations and clinical tests of a worker obtained and made under this Regulation and of the exposures of the worker to noise furnished by the employer under subsection 2 of section 15 shall be kept in a secure place by the physician who has conducted the examinations and tests or under whose supervision the examinations and tests have been made for,

(a) a period of forty years from the time such records were first made, or

(b) a period of twenty years from the time the last of such records were made,

whichever is the longer.

(2) Where the physician is no longer able or willing to keep the records, the records shall be forwarded to the Chief Physician, Occupational Health Medical Service, of the Ministry, or a physician designated by the Chief Physician and the provisions of subsection 1 shall, with necessary modifications, apply.

17. (1) The physician conducting the medical examination or clinical tests or under whose supervision the examination or tests are made shall advise the employer and the worker whether the worker is fit, or because of a condition resulting from exposure to noise is fit with limitations or unfit without giving or disclosing to the employer the records or results of the examination or tests, and in advising that the worker is fit with limitations, or unfit, the physician shall be governed by the provisions of the Code for Medical Surveillance for Noise.

(2) Where a worker is removed from exposure to noise because a physical examination or clinical test discloses that the worker may have or has a condition resulting from noise and suffers loss of earnings occasioned thereby, the worker is entitled to compensation for the loss in the manner and to the extent provided by The Workmen's Compensation Act.

(3) Copies of the exposure records and the records and results of medical examinations and clinical tests of a worker shall be given to the worker or his physician by the physician conducting the examinations or tests upon the request in writing of the worker or, in the case of a deceased worker, of his next of kin, and any authorization of another person by the worker or his next of kin to obtain and receive such copies is of no effect.

(4) Where the physician advises the employer that a worker, because of a condition resulting from exposure to noise, is fit with limitations or is unfit the physician shall forthwith communicate such advice to the Chief Physician, Occupational Health Medical Service, of the Ministry.

18. For the purposes of this Regulation the methods and procedures that may be used or adopted may vary from the Codes issued by the Ministry if the protection afforded thereby or the factors of accuracy and precision used or adopted are equal to or exceed the protection or the factors of accuracy and precision in the Codes issued by the Ministry.

19. Section 144 of the Ontario Regulation 658/79 is revoked.

20. (1) This Regulation, except sections 4 to 6, 8, 9, and 11 to 18 comes into force on the day this Regulation is filed.

(2) Sections 4 to 6, 8, 9, and 11 to 18 come into force ninety days after the day this Regulation is filed.

APPENDIX Jb

PROPOSED REGULATION UNDER THE OCCUPATIONAL HEALTH AND SAFETY ACT

NOISE - DESIGNATED SUBSTANCE

MINISTRY OF LABOUR
OCCUPATIONAL HEALTH AND SAFETY DIVISION

November 23, 1981

NOISE - DESIGNATED SUBSTANCE

1. In this Regulation,

(a) "A-weighting" means A-weighting as defined by the International Electrotechnical Commission (IEC) Standard 651-1979;

(b) "decibel" ("dB") means a dimensionless unit of sound pressure level or sound level;

(c) "decibel A-weighted" ("dBA") means a unit of sound pressure level modified by A-weighting;

(d) "equivalent sound exposure level" ("L_{ex}") means the steady sound level in dBA which, if present in a work place for 40 hours in one week, would contain the same total acoustic energy as that generated by the actual and varying sound levels to which a worker is taken to be exposed in one work week;

(e) "highway" means a highway as defined in the Highway Traffic Act;

(f) "impulse noise" and "impact noise" mean an impulsive sound caused by collision of solids or sudden pressure change in gases, either as a single pressure pulse or a single burst (multiple pressure pulses) having a duration less than one second with an interval between pulses greater than one second;

(g) "joint health and safety committee" includes a joint health and safety committee established under section 8 of the Act, a committee of like nature and the workers or their

representatives who participate in an arrangement, program or system conforming to subsection 8(2) of the Act;

(h) "noise" means a sound with an A-weighted sound pressure level equal to or greater than 80 dBA;

(i) "sound level" means the A-weighted sound pressure level;

(j) "sound pressure level" ("L_p") means 20 times the logarithm to the base 10 of the ratio of the root mean square ("rms") pressure of a sound to the root mean square of the reference pressure of 20 micropascals; and

(k) "vehicle" means a vehicle as defined in the Highway Traffic Act.

2. Noise is prescribed as a designated substance.

3. (1) Subject to subsection (3), this Regulation applies to every employer and worker at a work place where a worker is likely to be exposed to noise.

(2) Subject to subsection (3), an employer to whom this Regulation applies shall take every precaution reasonable in the circumstances to ensure that every worker who is not an employee of the employer but is working in the work place of the employer and is exposed to noise and whose health is likely to be affected thereby is protected and the worker shall comply with the requirements of the employer.

(3) Subsection 3(2) and sections 4 to 18 of this Regulation do not apply to,

(a) a constructor, an employer who is carrying out a project or a worker working on or at a project; or

(b) an employer of a worker working in or on a vehicle on a highway or to such a worker.

4. (1) Every employer shall take all necessary measures and procedures by means of engineering controls, work practices and hygiene practices and facilities to ensure that the exposure of a worker to noise during a work week does not exceed an equivalent sound exposure level (L_{ex}) of 90 dBA .

(2) Notwithstanding subsection (1), every employer shall take all necessary measures and procedures by means of engineering controls, work practices and hygiene practices and facilities to ensure that the exposure of a worker to noise which is not impulse or impact noise at no time exceeds 115 dBA, and in the case of exposure to impulse or impact noise, 135 dB.

(3) Subject to section 5, every employer shall comply with subsections (1) and (2) without requiring a worker to wear and use hearing protection equipment.

(4) Subject to section 17, the equivalent sound exposure level of noise, the impulse noise and the impact noise to which a worker is exposed shall be determined in accordance with the provisions in the Code for Noise Measurement dated the 23rd day of November, 1981, and issued by the Ministry.

(5) Every worker shall work in compliance with the work practices and hygiene practices in accordance with the provisions of the hearing conservation program.

(6) On a prosecution for a failure to comply with subsection (1) or (2) it shall be a defence for an employer to prove that he has complied with subsection (1) or (2) and that a breach of subsection (1) or (2) occurred solely because a worker failed to work in compliance

with the work practices and hygiene practices in accordance with the provisions of the hearing conservation program and the employer has taken every precaution reasonable in the circumstances to require the worker to do so.

5. (1) Where the strict duty imposed by subsection 4(1) or 4(2) cannot be complied with because,

(a) an emergency exists; or

(b) the measures and procedures necessary to control the exposure of a worker to noise,

(i) do not exist or are not available,

(ii) are not reasonable or are not practical for the length of time or frequency of exposure or the nature of the process, operation or work, or

(iii) are not effective because of a temporary breakdown of equipment,

the employer shall provide a worker with hearing protection equipment which shall be used by the worker.

(2) Where hearing protection equipment is provided by an employer and used by a worker, the hearing protection equipment shall be appropriate in the circumstances for the type and the levels of noise to which a worker is exposed and, subject to section 17, shall meet the requirements set out in the Code for Hearing Protection of Noise-Exposed Workers dated the 23rd day of November, 1981, and issued by the Ministry.

(3) The employer shall provide training and instruction to a worker in the proper care and use of hearing protection equipment provided by the employer.

6. (1) Every employer to whom this Regulation applies shall cause an assessment to be made in writing of the exposure or likelihood of exposure of a worker to noise in a work place.

(2) In causing the assessment to be made, the employer shall consider and take into account such matters as,

(a) the sources of noise;

(b) the extent and potential extent of the exposure of a worker to noise; and

(c) the measures and procedures necessary to control such exposure by means of engineering controls, work practices and hygiene practices and facilities.

(3) In causing the assessment to be made, the employer shall consult thereon with the joint health and safety committee and the committee may make recommendations with respect to the assessment.

(4) A copy of the assessment made by an employer shall be given by the employer to each member of the joint health and safety committee.

7. (1) Where the assessment discloses or would, if made in conformity with section 6, disclose that a worker is likely to be exposed to noise in excess of an 85 dBA sound level and that the health of the worker may be affected thereby, and in any event where the worker is exposed to noise in excess of an 85 dBA sound

level for 20 hours or more in a work week, the employer shall develop, establish, put into effect and maintain measures and procedures to control the exposure of the worker to noise and shall incorporate the same into a hearing conservation program.

(2) The hearing conservation program shall include provisions for,

(a) engineering controls, work practices and hygiene practices and facilities as required by sections 4 and 5;

(b) methods and procedures to monitor noise in the work place and the exposure of a worker thereto;

(c) personal records of the equivalent sound exposure level of the worker and of the sound levels and the times in which such sound levels were taken to be representative of the exposure of the worker to noise at the work place and used in calculating the equivalent sound exposure level to be maintained by the employer;

(d) medical examinations and clinical tests including audiometric tests of a worker; and

(e) records of medical examinations and clinical tests of a worker to be maintained by the physician who has examined the worker or under whose direction the clinical tests have been performed.

(3) In developing the measures and procedures mentioned in subsection (1) and the hearing conservation program, the employer shall consult with the joint health and safety committee and the committee may make recommendations with respect to the same.

8. Where a change is made in the work place which could result in a significant difference in the sound level to which the worker may be exposed, the employer shall cause a further assessment to be made forthwith and the provisions of sections 6 and 7 shall apply to the further assessment.

9. (1) Where disputes arise between an employer and a joint health and safety committee, as to an assessment required under section 6 or 8 or as to the measures and procedures mentioned in subsection 7(1) or the hearing conservation program or its provisions required under section 7 or 8, the employer, a member of the joint health and safety committee or the committee may notify an inspector thereof who shall investigate and give a decision in writing to the employer, the member or the committee.

(2) Nothing in subsection (1) applies so as to affect the power of an inspector to issue an order for a contravention of this Regulation.

10. (1) A copy of the hearing conservation program put into effect by the employer shall be given by the employer to each member of the joint health and safety committee and the employer shall acquaint every worker affected by the hearing conservation program with its provisions.

(2) A copy of the hearing conservation program put into effect by the employer shall be made available by the employer in English and in the majority language of the work place.

11. Subject to section 17, the procedures for monitoring and determining the sound level in a work place and the exposure of a worker thereto shall be those set out in the Code for Noise Measurement dated the 23rd day of November, 1981, and issued by the Ministry.

12. The results of monitoring of noise in the work place and the exposure of a worker thereto as provided by the hearing conservation program shall be,

(a) posted forthwith by the employer, as soon as the results are available, in a conspicuous place or places at the work place where they are most likely to come to the attention of the workers affected thereby, for a period of at least fourteen days;

(b) furnished to the joint health and safety committee; and

(c) kept by the employer for a period of at least five years.

13. (1) A worker shall, at the expense of the employer, undergo the medical examinations and clinical tests required under the hearing conservation program.

(2) Subject to section 17, the medical examinations and clinical tests required under the hearing conservation program shall meet the provisions of the Code for Medical Surveillance of Noise-Exposed Workers dated the 23rd day of November, 1981, and issued by the Ministry.

(3) Subject to section 17, the audiometric tests of a worker shall be determined in accordance with the Code for Audiometry of Noise-Exposed Workers dated the 23rd day of November, 1981, and issued by the Ministry.

14. (1) The records of the exposures of each worker to noise at the work place to be maintained as provided by the hearing conservation program shall identify the worker, including his date of birth, his jobs or occupations at the work place, the results of monitoring for his

exposure to noise in his work area and the use by the worker of hearing protection equipment and its type.

(2) The employer shall provide a copy of the records of the exposures of the worker to noise as provided by the hearing conservation program to the physician who examines the worker and under whose supervision the clinical tests of the worker are performed.

15. (1) The records of medical examinations and clinical tests of a worker obtained and made under this Regulation and of the exposures of the worker to noise furnished by the employer under subsection 14(2) shall be kept in a secure place by the physician who has conducted the examinations and tests or under whose supervision the examinations and tests have been made for,

(a) a period of forty years from the time such records were first made; or

(b) a period of twenty years from the time the last of such records were made,

whichever is the longer.

(2) Where the physician is no longer able or willing to keep the records, the records shall be forwarded to the Chief Physician, Occupational Health Medical Service of the Ministry, or a physician designated by the Chief Physician and the provisions of subsection (1) shall, with necessary modifications, apply thereto.

16. (1) The physician conducting the medical examination or clinical tests or under whose supervision the examination or tests are made shall advise the employer, who shall act thereon, and the worker whether the worker is fit, or because of a condition resulting from

exposure to noise is fit with limitations or unfit for work in noise without giving or disclosing to the employer the records or results of the examination or tests, and in advising that the worker is fit with limitations or unfit, the physician shall be governed by the provisions of the Code for Medical Surveillance of Noise-Exposed Workers referred to in subsection 13(2).

(2) Where a worker is removed from exposure to noise because a medical examination or clinical tests disclose that the worker may have or has a condition resulting from exposure to noise and suffers loss of earnings occasioned thereby, the worker is entitled to compensation for the loss in the manner and to the extent provided by the Workmen's Compensation Act.

(3) Upon advising the employer and the worker that a worker is fit with limitations or unfit for work in noise the physician shall advise in writing upon a confidential basis the joint health and safety committee thereof and in giving such advice shall indicate his opinion as to the interpretation to be placed thereon.

(4) Copies of the exposure records and the records and results of medical examinations and clinical tests of a worker shall be given by the physician conducting the examinations or tests,

(a) to the worker or his physician upon the request in writing of the worker; and

(b) in the case of a deceased worker, to the next of kin or personal representative of the worker, upon the request in writing of such next of kin or personal representative,

and any authorization of another person by the worker, his next of kin or personal representative is of no effect.

(5) Where the physician advises the employer that a worker, because of a condition resulting from exposure to noise, is fit with limitations or is unfit for work in noise, the physician shall forthwith communicate such advice to the Chief Physician, Occupational Health Medical Service of the Ministry.

17. For the purposes of this Regulation the methods and procedures that may be used or adopted may vary from the Codes issued by the Ministry if the protection afforded thereby or the factors of accuracy and precision used or adopted are equal to or exceed the protection or the factors of accuracy and precision in the Codes issued by the Ministry.

18. Section 144 of Regulation 692 of Revised Regulations of Ontario, 1980 is revoked.

19. (1) This Regulation, except sections 4, 5, 7, 8, and 10 to 18 comes into force on the day this Regulation is filed with the Registrar of Regulations.

(2) Sections 4,5,7,8, and 10 to 18 come into force 90 days after the day this Regulation is filed with the Registrar of Regulations.

APPENDIX Jc

PROPOSED REGULATION UNDER THE OCCUPATIONAL HEALTH AND SAFETY ACT

NOISE - DESIGNATED SUBSTANCE

MINISTRY OF LABOUR
OCCUPATIONAL HEALTH AND SAFETY DIVISION

November 10, 1982

NOISE - DESIGNATED SUBSTANCE

1. In this Regulation,

(a) "A-weighting" means A-weighting as defined by the International Electrotechnical Commission (IEC) Standard 651-1979;

(b) "decibel" ("dB") means a dimensionless unit of sound pressure level or sound level;

(c) "decibel A-weighted" ("dBA") means a unit of sound pressure level modified by A-weighting;

(d) "highway" means a highway as defined in the Highway Traffic Act;

(e) "impulse noise" and "impact noise" mean an impulsive sound caused by collision of solids or sudden pressure change in gases, either as a single pressure pulse or a single burst (multiple pressure pulses) having a duration less than one second with an interval between pulses greater than one second;

(f) "joint health and safety committee" includes a joint health and safety committee established under section 8 of the Act, a committee of like nature and the workers or their representatives who participate in an arrangement, program or system conforming to subsection 8(2) of the Act;

(g) "noise" means a sound with an A-weighted sound pressure level equal to or greater than 80 dBA and includes impulse and impact noise;

(h) "sound level" means the A-weighted sound pressure level;

(i) "sound pressure level" ("L_p") means 20 times the logarithm to the base 10 of the ratio of the root mean square ("rms") pressure of a sound to the root mean square of the reference pressure of 20 micropascals; and

(j) "vehicle" means a vehicle as defined in the Highway Traffic Act.

2. The purpose of this Regulation is the reduction of noise to the lowest practical level so as to afford maximum protection to workers.

3. Noise is prescribed as a designated substance.

4. (1) Subject to subsection (3), this Regulation applies to every employer and worker at a work place where a worker is likely to be exposed to noise.

(2) Subject to subsection (3), an employer to whom this Regulation applies shall take every precaution reasonable in the circumstances to ensure that every worker who is not an employee of the employer but is working in the work place of the employer and is subjected to noise and whose health is likely to be affected thereby is protected and the worker shall comply with the requirements of the employer.

(3) Subsection 4(2) and sections 5 to 22 of this Regulation do not apply to,

(a) a constructor, an employer who is carrying out a project or a worker working on or at a project; or

(b) an employer in respect of a worker in or on a vehicle being operated on a highway or to such a worker.

5. (1) Where the sound level of noise in a work place to which a worker is or would be subjected is equal to or greater than 90 dBA the employer shall take all necessary measures by means of engineering controls to ensure that the sound level is reduced to the lowest practical level and in any case the level be reduced to below 90 dBA.

(2) On a prosecution for a failure to comply with subsection (1) it shall be a defence for an employer to prove that he has complied with subsection (1) and that a breach of subsection (1) occurred solely because a worker failed to work in compliance with work practices specified in the hearing conservation program established under subsection 12(2).

6. Where the strict duty imposed by section 5 cannot be complied with because,

(a) an emergency exists, or

(b) the measures and procedures necessary to control the sound levels,

(i) do not exist or are not available,

(ii) are not reasonable or practical for the length of time or frequency of exposure or the nature of the process, operation or work, or

(iii) are not effective because of a temporary breakdown of a measure or procedure necessary to control the sound levels,

the employer shall provide a worker with hearing protection equipment which shall be used by the worker.

7. Where engineering controls come into existence through the development of knowledge and technology and would, if adopted and implemented by an employer, reduce the sound level below the sound level mentioned in section 5, the employer shall adopt and implement the engineering controls where it is reasonable or practical so to do.

8. Where the sound level of noise in a work place to which a worker is or would be subjected is equal to or greater than 85 dBA for four hours or more in a work day, the employer shall provide hearing protection equipment to the worker and the equipment shall be used by the worker.

9. Subject to section 21 the sound levels shall be determined in accordance with the provisions in the Code for Noise Measurement dated the 5th day of November,1982, and issued by the Ministry.

10. (1) Hearing protection equipment shall be appropriate in the circumstances for the type and levels of noise to which a worker would be subjected and, subject to section 21, shall meet the requirements set out in the Code for Hearing Protection of Noise-Exposed Workers dated the 5th day of November, 1982, and issued by the Ministry.

(2) The employer shall provide training and instruction to a worker in the proper care and use of hearing protection equipment provided by the employer.

(3) Clearly visible warning signs shall be posted at the approaches to an area where the sound level is equal to or greater than 85 dBA for four or more hours in a work day warning that hearing protection equipment shall be worn in the area.

11. (1) Every employer to whom this Regulation applies shall cause an assessment to be made in writing of the sound levels of noise to which a

worker is subjected or is likely to be subjected.

(2) In causing the assessment to be made, the employer shall consider and take into account such matters as,

(a) the sources of noise;

(b) the extent and potential extent to which a worker would be subjected to sound levels of noise; and

(c) the measures and procedures necessary to control the sound levels of noise by means of engineering controls, work practices and facilities.

(3) In causing the assessment to be made, the employer shall consult thereon with the joint health and safety committee and the committee may make recommendations with respect to the assessment.

(4) A copy of the assessment made by an employer shall be given by the employer to each member of the joint health and safety committee.

12. (1) Where the assessment discloses or would, if made in conformity with section 11, disclose that the sound level of noise in a work place to which a worker is or is likely to be subjected to noise is,

(a) equal to or greater than a sound level of noise of 85 dBA for four hours or more in a work day, or

(b) equal to or greater than a sound level of noise of 90 dBA,

the employer shall develop, establish, put into effect and maintain a hearing conservation program.

(2) The hearing conservation program shall include provisions for,

(a) hearing protection equipment;

(b) methods and procedures to monitor noise in the work place to which a worker is subjected;

(c) records of the sound levels of noise and the times in which such sound levels were taken as being representative of the sound levels to which a worker is subjected at the work place to be maintained by the employer;

(d) medical examinations and clinical tests including audiometric tests of a worker;

(e) records of medical examinations and clinical tests of a worker to be maintained by the physician who has examined the worker or under whose direction the clinical tests have been performed; and

(f) work practices and facilities;

(g) engineering controls, as prescribed by section 5.

(3) In developing the measures and procedures mentioned in subsection (2) the employer shall consult with the joint health and safety committee and the committee may make recommendations with respect to the same.

13. Where a change is made in the work place which could result in a significant difference in the sound level of noise to which the worker may be exposed, the employer shall cause a further assessment to be made forthwith and the provisions of sections 11 and 12 shall apply to the further assessment.

14. (1) Where disputes arise between an employer and a joint health and safety committee, as to an assessment required under section 11 or 13 or as to the measures and procedures required to be included in the hearing conservation program or its provisions required under section 12 or 13, the employer, a member of the joint health and safety committee or the committee may notify an inspector thereof who shall investigate and give a decision in writing to the employer, the member or the committee.

(2) Nothing in subsection (1) applies so as to affect the power of an inspector to issue an order for a contravention of this Regulation.

15. (1) A copy of the hearing conservation program put into effect by the employer shall be given by the employer to each member of the joint health and safety committee and the employer shall acquaint every worker affected by the hearing conservation program with its provisions.

(2) A copy of the hearing conservation program put into effect by the employer shall be made available by the employer in English and in the majority language of the work place.

16. The results of monitoring of noise in the work place as provided by the hearing conservation program shall be,

(a) posted forthwith by the employer, as soon as the results are available, in a conspicuous place or places at the work place where they are most likely to come to the attention of the workers affected thereby, for a period of at least fourteen days;

(b) furnished to the joint health and safety committee; and

(c) kept by the employer for a period of at least five years.

17. (1) A worker shall, at the expense of the employer, undergo the medical examinations and clinical tests required under the hearing conservation program.

(2) Subject to section 21, the medical examinations and clinical tests required under the hearing conservation program shall meet the provisions of the Code for Medical Surveillance of Noise-Exposed Workers dated the 5th day of November, 1982, and issued by the Ministry.

(3) Subject to section 21, the audiometric tests of a worker shall be determined in accordance with the Code for Audiometry of Noise-Exposed Workers dated the 5th day of November, 1982, and issued by the Ministry.

18. (1) The records of the sound levels to which a worker is subjected at the work place to be maintained as provided by the hearing conservation program shall identify the worker, including his date of birth, his jobs or occupations at the work place, the results of monitoring for noise in his work area and the use by the worker of hearing protection equipment and its type.

(2) The employer shall provide a copy of the records of the sound levels to which a worker is subjected as provided by the hearing conservation program to the physician who examines the worker and under whose supervision the clinical tests of the worker are performed.

19. (1) The records of medical examinations and clinical tests of a worker obtained and made under this Regulation and of the exposures of the worker to noise furnished by the employer under subsection 18(2) shall be kept in a secure place by the physician who has conducted the examinations and tests or under whose supervision the examinations and tests have been made for,

(a) a period of forty years from the time such records were first made; or

(b) a period of twenty years from the time the last of such records were made,

whichever is the longer.

(2) Where the physician is no longer able or willing to keep the records, the records shall be forwarded to the Chief Physician, Occupational Health Medical Service of the Ministry, or a physician designated by the Chief Physician and the provisions of subsection (1) shall, with necessary modifications, apply thereto.

20. (1) The physician conducting the medical examination or clinical tests or under whose supervision the examination or tests are made shall advise the employer, who shall act thereon, and the worker whether the worker is fit, or, because of a condition resulting from exposure to noise, is fit with limitations or unfit for work in noise without giving or disclosing to the employer the records or results of the examination or tests, and in advising that the worker is fit with limitations or unfit, the physician shall be governed by the provisions of the Code for Medical Surveillance of Noise-Exposed Workers referred to in subsection 17(2).

(2) Where a worker is removed from exposure to noise because a medical examination or clinical tests disclose that the worker may have or has a condition resulting from exposure to noise and suffers loss of earnings occasioned thereby, the worker is entitled to compensation for the loss in the manner and to the extent provided by the Workmen's Compensation Act.

(3) Upon advising the employer and the worker that a worker is fit with limitations or unfit for work in noise the physician shall advise in writing upon a confidential basis the joint health and safety committee

thereof and in giving such advice shall indicate his opinion as to the interpretation to be placed thereon.

(4) Copies of the records of the sound levels to which a worker is subjected and the records and results of medical examinations and clinical tests of a worker shall be given by the physician conducting the examinations or tests,

(a) to the worker or his physician upon the request in writing of the worker; and

(b) in the case of a deceased worker, to the next of kin or personal representative of the worker, upon the request in writing of such next of kin or personal representative,

and any authorization of another person by the worker, his next of kin or personal representative is of no effect.

(5) Where the physician advises the employer that a worker, because of a condition resulting from exposure to noise, is fit with limitations or is unfit for work in noise, the physician shall forthwith communicate such advice to the Chief Physician, Occupational Health Medical Service of the Ministry.

21. For the purposes of this Regulation the methods and procedures that may be used or adopted may vary from the Codes issued by the Ministry if the protection afforded thereby or the factors of accuracy and precision used or adopted are equal to or exceed the protection or the factors of accuracy and precision in the Codes issued by the Ministry.

22. Section 144 of Regulation 692 of Revised Regulations of Ontario, 1980 is revoked.

23. (1) This Regulation, except sections 5 to 10, 12, 13 and 15 to 22 comes into force on the day this Regulation is filed with the Registrar of Regulations.

(2) Sections 5 to 10, 12, 13 and 15 to 22 come into force 90 days after the day this Regulation is filed with the Registrar of Regulations.

APPENDIX Ka

CODE FOR HEARING PROTECTION OF NOISE-EXPOSED WORKERS

June 23, 1981

Occupational Health Branch
Onatrio Ministry of Labour

APPENDIX Ka

CODE FOR HEARING PROTECTION OF NOISE-EXPOSED WORKERS

Table of Contents

Standard	Ka.1
Purpose	Ka.1
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1. **Standard.**

Hearing protective equipment provided by an employer and used by a worker shall meet or exceed the specification of the CSA standard Z 94.2 1974 - Hearing Protectors and shall be appropriate for the type and sound levels of noise to which the worker is exposed.

2. **Purpose.**

(i) Hearing protectors provide the employer with an interim measure for noise control. Hearing protectors are secondary to the control of noise through engineering.

(ii) Hearing protectors provide the worker with effective attenuation of noise before it reaches the inner ear to cause a temporary or a permanent noise induced hearing loss.

3. **Types of Hearing Protectors.**

There are two types of hearing protectors appropriate for use in industry: earplugs and earmuffs.

Earplugs

Earplugs are worn in the ear and provide an acoustic seal at the entrance of the ear canal. There are several designs of earplugs including premolded, custom molded and formable.

Premolded earplugs are made of soft flexible material and are available in a range of different shapes and sizes. These earplugs require each ear to be fitted separately.

Custom molded earplugs are made of rubber-like material, formed by

taking an impression of the ear. Both the impression and the construction of the earmold require that they be performed by a skilled individual.

A variation of the custom molded earplugs is the plastic caps which are attached to a headband and seated at the entrance of the ear canal.

Formable earplugs are made of swedish wool, wax impregnated cotton or expandable foam. These earplugs are formed in the hand and then inserted into the ear canal. They are designed to fit all ears and to be disposable after one or several applications.

Earmuffs

Earmuffs are worn over the outer ear and provide an acoustic seal against the head. They consist of earcups and earcushions supported by a headband with a spring loaded assembly.

The earcups are made of rigid, dense plastic and partially filled with high frequency absorptive material. The ear cushions are made of smooth, pliable plastic and filled with liquid or foam. The earcups and the headband are designed to be adjusted to the shape and size of the head.

Prior to a decision to purchase earplugs or earmuffs, the practical advantages of one over the other should be given some consideration. These are summarized below:

Earplugs

(i) They are small and easily carried.

(ii) They are convenient for use with other protective equipment.

(iii) They are comfortable in hot, humid work areas.

(iv) They are convenient for use in confined areas.

Earmuffs

(i) They are designed so that one size fits most head sizes.

(ii) They are easily seen at a distance to assist in the monitoring of their use.

(iii) They may be worn with minor ear infections.

(iv) They are not easily misplaced or lost.

4. Selection and Evaluation of Hearing Protectors.

After consideration has been given to the practical advantages of earplugs and earmuffs, the employer must select a hearing protector that will provide effective attenuation for the worker in a specific noise environment. Effective attenuation is the 'real world' attenuation of ambient noise in the workplace when measured at the ear of the worker.

To determine whether a particular hearing protector is appropriate for use by a worker in his work area requires the comparison of hearing protector attenuation data (provided on the manufacturer's specification sheets) with the noise measurement data.

There are several methods for drawing comparisons between the two sets of data. Two methods are summarized below.

Method 1.

A hearing protector is appropriate if it meets the requirements according to the mean attenuation values of the CSA standard Z 94.2 1975 - Hearing Protectors for Class A or B rating. Hearing protectors classified as such must be used where the noise

measurements yield the following results:

Sound Levels dB(A)	Hearing Protector
85 - 100	Class B
101 - 115	Class A
Impact - 135	Class A

Method 2(a)

A hearing protector is appropriate if the estimated attenuation of the protector reduces the ambient noise to a target sound level of 80 dB(A). To estimate the attenuated sound level with a hearing protector requires the following measurements and calculations to be carried out:

(i) measure the octave band sound levels in dB from L_{250} to L_{8000} where L_{250} is the sound pressure level of the octave band centred at 250 Hz.

(ii) calculate the A weighted octave band sound levels from the A weighted correction factors (see Table I, p.6).

(iii) calculate the A weighted octave band sound levels reaching the ear while wearing the hearing protector by: subtracting the mean attenuation values minus two times the standard deviations (a correction factor to assure that the attenuation values are actually realized by most workers) from the A weighted octave band sound levels obtained in (ii).

(iv) calculate the overall A weighted sound level with the hearing protector by adding the A weighted octave band sound levels in (iii) using either Table II (p.7) or the formula:

$$\text{Overall dB(A)} = 10 \log \sum_{i=1}^{6} 10^{Li/10}$$

EXAMPLE

(i) measure the octave band sound levels from L_{250} - L_{8000}

L_i =	250	5000	1000	2000	4000	8000
	94	94	95	97	95	91

(ii) calculate the A weighted octave band sound levels using L_i in (i) and A weighted corrections in Table I.

L_i =	94	94	95	97	95	91
A weighted correction=	-9	-3	-0	+1	+1	-1

The A weighted octave band sound levels are:

	85	91	95	98	96	90

(iii) calculate the A weighted octave band sound levels reaching the ear while wearing the hearing protector by:

recording the mean attenuation values from the manufacturer's specification sheets

22	23	29	41	43	37

subtracting two times the standard deviations

(2x3.3)	(2x3.8)	(2x9.7)	(2x3.3)	(2x2.7)	(2x6.6)

The attenuation values of the Hearing Protector with the correction factor are:

15.4	15.4	19.6	34.4	37.6	23.8

The A weighted octave band sound levels reaching the ear with the hearing protector are:

(85-15.4)	(91-15.4)	(95-19.6)	(98-34.4)	(96-37.6)	(90-23.8)
69.6	75.6	75.4	63.6	58.4	66.2

(iv) The overall A weighted sound level with the hearing protector is 79.4 dB(A).

Method 2(b)

When the manufacturer's specifications include the noise reduction rating (NRR), this single number provides an alternate method for estimation of the attenuated sound level while wearing a hearing protector. The method requires the following measurements and calculations:

(i) carry out sound level measurements dB(C) and dB(A) according to sampling procedures described under area noise monitoring - Code for Noise Measurement;

(ii) calculate the overall sound levels dB(C) and dB(A) using Table II or formula method 2(a) step (iv);

(iii) subtract the overall sound level dB(A) from the overall sound level dB(C) to assess the relative contribution of low frequencies. If there is a considerable difference more than 7 dB, it is advisable not to use this method. If the difference is less than 7 dB then substitute computed values in formula:

Sound level with hearing protection dB(A) = dB(C) - NRR - 3 dB

Note: 3 dB is a correction factor to protect against over-estimating the hearing protector's noise reduction capability because of variation in industrial sound spectra.

(iv) the target sound level with the hearing protector should be 80 dB(A).

EXAMPLE

105 dB(C) - 25 dB NRR - 3 dB = 77 dB(A)

Table I

Octave band centre frequency, Hz	250	500	1000	2000	4000	8000
A-weighted corrections, dB	-9	-3	0	+1	+1	-1

ISO 1999 - 1975 (E)

Table II

TABLE FOR COMBINING DECIBEL LEVELS

Sum L_T of dB Levels L_1 and L_2

Numerical Difference Between Levels L_1 and L_2	L_3 Amount to be Added to the Higher of L_1 or L_2
0.0 to 0.1	3.0
0.2 to 0.3	2.9
0.4 to 0.5	2.8
0.6 to 0.7	2.7
0.8 to 0.9	2.6
1.0 to 1.2	2.5
1.3 to 1.4	2.4
1.5 to 1.6	2.3
1.7 to 1.9	2.2
2.0 to 2.1	2.1
2.2 to 2.4	2.0
2.5 to 2.7	1.9
2.8 to 3.0	1.8
3.1 to 3.3	1.7
3.4 to 3.6	1.6
3.7 to 4.0	1.5
4.1 to 4.3	1.4
4.4 to 4.7	1.3
4.8 to 5.1	1.2
5.2 to 5.6	1.1
5.7 to 6.1	1.0
6.2 to 6.6	0.9
6.7 to 7.2	0.8
7.3 to 7.9	0.7
8.0 to 8.6	0.6
8.7 to 9.6	0.5
9.7 to 10.7	0.4
10.8 to 12.2	0.3
12.3 to 14.5	0.2
14.6 to 19.3	0.1
19.4 to	0.0

Step 1: Determine the difference between the two levels to be added (L_1 and L_2).

Step 2: Find the number (L_3) corresponding to this difference in the Table.

Step 3: Add the number (L_3) to the highest of L_1 and L_2 to obtain the resultant level ($L_R = L_1 + L_2$).
$L_T = L1 + L2$.

5. **General Requirements for Use of Hearing Protectors**

(i) An otoscopic examination must be performed prior to fitting for hearing protectors. Where fitting is pre-placement, the worker must be informed of the company policy regarding the use of personal protective equipment, the rationale for use of hearing protectors and the effects of noise on hearing.

(ii) The worker must participate in the selection and fitting of hearing protectors. He/she must be given a choice from among several types of appropriate hearing protectors and a trial period with each of these, if necessary.

(iii) When earplugs are selected, the ear canals must be individually appraised for correct size and shape of hearing protector.

(iv) Hearing protectors must be fitted in accordance with the manufacturer's instructions. These instructions must be given to the worker and reviewed with him/her.

(v) Hearing protectors must be fitted for comfort and for an effective seal between the earplug and the ear canal or between the earmuff cushion and the head. There should be no

leaks through or around the hearing protector.

(vi) The proper fitting technique must be demonstrated and this technique practised by the worker under close supervision.

For proper fitting of earplugs, the ear should be pulled up and back with the opposite hand, to enlarge and straighten the ear canal. The earplug should then be inserted and the ear released. Earplugs must be reseated several times during the workshift.

For proper fitting of earmuffs, hair and clothing should be pushed back away from the ear and the earmuff cushions placed directly over the ears. The headband then must be adjusted for a snug fit.

(vii) Workers must be instructed in the proper care and use of hearing protectors.Earplugs must be kept clean and in good working condition. Earmuff cushions must be pliable and the headband tension sufficient to seal against the head.

(viii) The condition and fit of hearing protectors must be evaluated at the time of the annual audiometric test. Defective hearing protectors, poorly fitting hearing protectors and improper fitting technique must be identified, recorded and corrected.

(ix) Replacement hearing protectors (earplugs or earmuff cushions) must be stored in a convenient and clean location in the work area.

(x) Signs must be posted in the work area to remind the worker to wear his/her hearing protectors.

(xi) The care, use and wearing of hearing protectors by a worker in the work area must be periodically supervised. Workers who demonstrate significant deterioration in hearing on annual audiometric testing must be supervised more closely and more often.

(xii) Records must be kept to monitor the worker's use of hearing protectors including: the type and brand name, the date issued and the duration of use.

APPENDIX Kb

CODE FOR HEARING PROTECTION OF NOISE-EXPOSED WORKERS

MINISTRY OF LABOUR
OCCUPATIONAL HEALTH AND SAFETY DIVISION
November 23, 1981

CODE FOR HEARING PROTECTION OF NOISE-EXPOSED WORKERS

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2.	Purpose	Kb.1
3.	Types of Hearing Protectors	Kb.1
4.	Selection of Hearing Protectors	Kb.2
5.	General Requirements for Use of Hearing Protectors	Kb.6

1. Standard

Hearing protective equipment provided by an employer and used by a worker must meet or exceed the specifications of the CSA Standard Z94.2-1974 (Amended 1979) "Hearing Protectors" and must be appropriate for the type and level of noise to which the worker is exposed.

2. Purpose

(1) Hearing protectors provide the employer with an interim measure for noise control. The use of hearing protectors is secondary to the control of noise at the source through engineering.

(2) Hearing protectors provide the worker with effective attenuation of noise before it reaches the inner ear to cause a temporary or a permanent threshold shift.

3. Types of Hearing Protectors

There are three types of hearing protectors appropriate for use in industry: inserts or earplugs, semi-inserts and earmuffs.

Earplugs

Earplugs are worn in the ear and provide an acoustic seal at the entrance to the external ear canal. There are several different designs of earplugs including premolded, custom molded and formable.

Semi-Inserts

Semi-inserts are worn in the ear and provide an acoustic seal at the

entrance to the external ear canal. They consist of premolded earplugs supported by a headband.

Earmuffs

Earmuffs are worn over the outer ear and provide an acoustic seal against the head. They consist of earcups and earcushions supported by a headband with a spring loaded assembly.

4. Selection of Hearing Protectors

There are two criteria for the selection of earplugs or earmuffs, both of which must be addressed prior to a decision to purchase.

The first criterion involves evaluation of the attenuation characteristics of the earplug or earmuff to determine if the hearing protector will provide effective attenuation for a worker in a specific noise environment.

The second criterion is the evaluation of the advantages and disadvantages of an earplug or earmuff to determine if the hearing protector will be acceptable for use by a worker in a specific noise environment.

These two criteria, i.e. evaluation of attenuation characteristics and evaluation of advantages and disadvantages of hearing protectors, are the basis for defining "appropriate" hearing protection, as required in section 5(2) of the Regulation.

(1) Evaluation of Attenuation Characteristics

A hearing protector must provide the worker with effective attentuation of noise in the work place. Effective attenuation for purposes of this code is defined as the reduction of ambient

noise at the worker's ear to a target sound level of 85 dBA.

To evaluate if an earplug or an earmuff will provide effective attentuation, the attenuation data (provided by the manufacturer) must be compared with the noise measurement data.

There are several methods for carrying out these comparisons. One of the following must be used:

(a) **Method 1**

A hearing protector may be selected if it meets the requirements for Class A or B rating according to the mean sound attenuation data specified in the CSA Standard Z94.2-1974, (Amended 1979) "Hearing Protectors". Earplugs or earmuffs with Class A or B rating must be used when noise measurements yield the following results:

Sound Level		Hearing Protector Class
Steady State	80 - 89 dBA	C
Steady State	90 - 105 dBA	B
Steady State	over 105 dBA	A
Impulse (peak pressure)	over 115 dB	A

Noise measurements must be carried out according to the procedures described under section 3 in the Code for Noise Measurement dated the 23rd day of November, 1981 and must reflect the highest noise levels to which the worker is exposed.

(b) **Method 2**

A hearing protector may be selected if the Noise Reduction Rating (NRR) reduces the ambient noise in the work place to a target sound level of 85 dBA. To estimate the sound level with the hearing protector using the NRR, proceed as follows:

(i) carry out C-weighted sound level measurements according to the sampling procedures described under section 3 in the Code for Noise Measurement dated the 23rd day of November, 1981;

(ii) determine the highest sound level in dBC to which the worker is exposed; and

(iii) calculate the A-weighted sound level with the hearing protector by subtracting the NRR from the C-weighted sound level:

dBA = dBC - NRR.

To protect against the over-estimation of the noise reduction capability of the hearing protector, the NRR must include a correction factor of at least 3 dB.

(c) **Method 3**

A hearing protector may be selected if the estimated attenuation of the earplug or earmuff reduces the ambient noise to a target sound level of 85 dBA. To estimate the sound level with the hearing protector, proceed as follows:

(i) measure the sound pressure level in dB of the octave bands centered from 250-8000 Hz according to the procedures described under section 3(4)(e) in the Code for Noise Measurement dated the 23rd day of November, 1981;

(ii) calculate the A-weighted sound pressure level in dB of the octave bands using the A-weighted corrections as specified in the International Electrotechnical Commission (IEC) Standard 651-1979;

(iii) calculate the A-weighted sound pressure levels in dB of the octave bands with the hearing protector by subtracting the mean attenuations minus two times the standard deviation (a correction factor to assure that the attenuation values are actually realized by most workers) from the A-weighted sound pressure levels in dB of the octave bands; and

(iv) calculate the overall A-weighted sound pressure level (dBA) with the hearing protector by adding the A-weighted sound pressure level in dB of the octave bands using the formula under section 3(4)(e) in the Code for Noise Measurement dated the 23rd day of November, 1981.

(2) **Evaluation of Advantages and Disadvantages**

The selection process also requires that consideration be given to the general advantages and disadvantages of earplugs and earmuffs. These are summarized below:

(a) Earplugs

(i) They are small and easily carried.

(ii) They are convenient for use with other personal protection equipment.

(iii) They are more comfortable in hot, humid work areas.

(iv) They are convenient for use in confined work areas.

(v) They may require more time to fit.

(vi) They may be more difficult to insert and remove.

(vii) They require good hygiene practices to be followed.

(viii) They may irritate the skin of the ear canal.

(b) Earmuffs

(i) They are designed so that one size fits most head sizes.

(ii) They are easily seen at a distance to assist in the monitoring of their use.

(iii) They are not easily misplaced or lost.

(iv) They may be worn with minor ear infections.

(v) They are heavier and less portable.

(vi) They may be more inconvenient for use with other personal protective equipment.

(vii) They may be more uncomfortable in hot, humid work areas.

(viii) They may be more inconvenient for use in confined work areas.

5. **General Requirements for Use of Hearing Protectors**

(1) Prior to fitting for hearing protection, a worker must be

informed of the rationale for use of earplugs or earmuffs and the effects of noise on hearing. This information must be incorporated into an instructional training program.

(2) The worker should be given a choice from among several types of appropriate hearing protectors (as defined in section 3) and a trial period provided with each of these, if necessary.

(3) When premolded or custom molded earplugs are selected, the ear canals must be checked and individually appraised for correct size and shape of hearing protector.

(4) Hearing protectors must be fitted in accordance with the instructions provided by the manufacturer. These instructions must be given to the worker and reviewed with him.

(5) The proper fitting technique for earplugs and earmuffs must be demonstrated and the technique practised by the worker under close supervision.

For proper fitting of earplugs, the ear should be pulled up and back with the opposite hand, to enlarge and straighten the ear canal. If earplugs are removed, good hygiene practice must be followed before earplugs are reseated.

For proper fitting of earmuffs, hair and clothing should be pushed back away from the ear and the earmuff cushions placed directly over the ears. The headband then must be adjusted for a snug fit.

(6) Hearing protectors must achieve an effective seal between the earplug and the ear canal or between the earmuff cushion and the head. The worker must be able to tolerate the use of the

hearing protector throughout the work shift.

(7) Earplugs must be kept clean and in the best operative condition. Earmuff cushions must be pliable and the headband tension sufficient to maintain a seal against the head.

(8) The condition and fit of hearing protectors must be examined periodically in the work area and at the time of the audiometric test. Defects in hearing protectors must be corrected.

(9) The care, use and wearing of hearing protectors by workers who demonstrate significant deterioration in hearing on audiometric tests must be monitored more closely and more frequently.

(10) Replacement hearing protectors of the appropriate type must be stored in a convenient location in the work area.

(11) Clearly visible warning signs must be posted in work areas where workers use hearing protection as permitted under section 5 of the Regulation.

(12) Records of frequency of use by the worker of hearing protectors, their type and brand name are to be kept.

APPENDIX Kc

CODE FOR HEARING PROTECTION OF NOISE-EXPOSED WORKERS

MINISTRY OF LABOUR
OCCUPATIONAL HEALTH AND SAFETY DIVISION
November 5, 1982

0830111782

CODE FOR HEARING PROTECTION OF NOISE-EXPOSED WORKERS

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0830111782

1.1 Purpose

(1) Hearing protection provides the employer with an interim measure for noise control. The use of hearing protection is secondary to the control of noise at the source through engineering.

(2) Hearing protection provides the worker with effective attenuation of noise before it reaches the inner ear to cause a temporary or a permanent threshold shift.

2. Definitions

Hearing Protector: A device worn to prevent the harmful effects of sound on the auditory system.

Earplug: A hearing protector worn within the external ear canal (aural) or in the concha against the entrance to the external ear canal (semi-aural).

Earmuff: A hearing protector comprised of headband and earcups with a soft outer ring intended to fit snugly against the pinna (supra-aural) or the sides of the head around the pinna (circumaural).

Communication Headset: A device (earplug or earmuff) designed primarily for communication which may also provide hearing protection.

Helmet: A device which may include hearing protection and which covers a substantial part of the head.

Sound Attenuation: At a given test signal, the mean value of the differences in decibels between thresholds of audibility with and without hearing protection.

Threshold of Audibility: The minimum sound pressure level of a signal capable of evoking an auditory sensation for a specified number of trials. The characteristics of the signal, the manner in which it is presented and the point at which it is measured are specified.

3. Types of Hearing Protectors

All types of hearing protectors as defined in Section 2 qualify for use in industry.

Hearing protective equipment provided by an employer and used by a worker must meet or exceed the specifications of the CSA Standard Z94.2-1974 (Amended 1979) "Hearing Protectors" and must be appropriate for the type and level of noise to which the worker is exposed.

4. Selection of Hearing Protectors

In the selection of hearing protection, three criteria must be considered: sound attenuation, application and comfort. These criteria form the basis for defining "appropriate" hearing protection as required in Section 10(1) of the Regulation and must be addressed by the employer, prior to purchase or provision to workers.

(1) Sound Attenuation

The sound attenuation characteristics of a hearing protector must be evaluated to determine if it will provide effective attenuation for a particular worker in a specific noise environment.

Effective sound attenuation for purposes of this code is defined as the reduction of ambient noise at the worker's ear to a target sound level of 85 dBA.

To evaluate if a hearing protector will provide effective sound attentuation, the sound attenuation data (provided by the manufacturer) must be compared with the noise measurement data.

There are two methods for carrying out these comparisons. One of the following must be used:

(a) **Method 1**

A hearing protector may be selected if the Noise Reduction Rating (NRR) reduces the ambient noise in the work place to a target sound level of 85 dBA. To estimate the sound level with the hearing protector using the NRR, proceed as follows:

(i) carry out C-weighted sound level measurements according to the sampling procedures described under section 3 in the Code for Noise Measurement.

(ii) determine the highest sound level in dBC to which the worker is exposed; and

(iii) calculate the A-weighted sound level with the hearing protector by subtracting the NRR from the C-weighted sound level:

dBA = dBC - NRR.

To protect against the over-estimation of the noise reduction capability of the hearing protector, the NRR must include a correction factor of at least 3 dB.

(b) **Method 2**

A hearing protector may be selected if the estimated sound attenuation reduces the ambient noise to a target sound level of 85 dBA. To estimate the sound level with the hearing protector, proceed as follows:

(i) measure the sound pressure level in dB of the octave bands centered from 250-8000 Hz according to the procedures described under section 3 in the Code for Noise Measurement;

(ii) calculate the A-weighted sound pressure level in dB of the octave bands using the A-weighted corrections as specified in the International Electrotechnical Commission (IEC) Standard 651-1979;

(iii) calculate the A-weighted sound pressure levels in dB of the octave bands with the hearing protector by subtracting the mean attenuations minus two times the standard deviation (a correction factor to assure that the attenuation values are actually realized by most workers) from the A-weighted sound pressure levels in dB of the octave bands; and

(iv) calculate the overall A-weighted sound pressure level (dBA) with the hearing protector by adding the A-weighted sound pressure level in dB of the octave bands using the formula under section 3 in the Code for Noise Measurement.

Where noise levels in the work place are excessive and a target sound level of 85 dBA may not be achievable, consideration must be given to the following:

(1) Combined fitting of hearing protectors, i.e. earplugs and earmuffs to reduce noise by 3 dB.

(2) Alternate methods to reduce noise and control worker noise exposure as specified under the provisions for the Hearing Conservation Program in Section 12(2) of the Regulation.

(2) **Application**

The application of a hearing protector must be evaluated to determine if it is suitable for use by a particular worker in a specific noise environment.

To evaluate the application of a hearing protector, consideration must be given to the general advantages and disadvantages among hearing protectors. These are summarized below:

(a) Earplugs

(i) They are small and easily carried.
(ii) They are convenient for use with other personal protective equipment.
(iii) They are more comfortable in hot, humid work areas.
(iv) They are convenient for use in confined work areas.
(v) They may require more time to fit.
(vi) They may be more difficult to insert and remove.
(vii) They require good hygiene practices to be followed.
(viii) They may irritate the skin of the ear canal.

(b) Earmuffs

(i) They are designed so that one size fits most head sizes.

(ii) They are easily seen at a distance to assist in the monitoring of their use.

(iii) They are not easily misplaced or lost.

(iv) They may be worn with minor ear infections.

(v) They are heavier and less portable.

(vi) They may be more inconvenient for use with other personal protective equipment.

(vii) They may be more uncomfortable in hot, humid work areas.

(viii) They may be more inconvenient for use in confined work areas.

(3) **Comfort**

The comfort of a hearing protector must be evaluated to determine if it will be accepted and worn by a particular worker.

To evaluate the comfort of a hearing protector, the worker must be given a choice from among several types of hearing protectors which meet the first two selection criteria, and a trial period provided with each of these, if necessary.

The worker should be able to tolerate the use of the hearing protector throughout the entire noise exposure period.

5. **General Requirements for Use of Hearing Protectors**

(1) Prior to fitting for hearing protection, a worker must be informed of the purpose and components of a Hearing Conservation Program, the rationale for use of hearing protectors and the

effects of noise on hearing. This information must be incorporated into training and instruction for the worker as required in section 10(2) of the Regulation.

(2) Before fitting hearing protectors, a visual inspection of the external ear should be carried out to identify ear problems i.e. (impacted wax, infection or discharge) which may interfere with or be aggravated by the use of hearing protectors. If any of these conditions are identified, the worker should be referred for medical investigation. When premolded or custom molded ear plugs are selected, the ear canals should be individually appraised for correct size and shape of hearing protector.

(3) The selection and fitting of hearing protectors should involve the worker. He/she should be given a choice from among several types of appropriate hearing protectors i.e. at least two ear plugs and one ear muff. A trial period should be provided with each of these if necessary.

(4) Hearing protectors should be fitted in accordance with the manufacturer's instructions when available, and these reviewed with the worker. Hearing protectors are properly fitted when there are no leaks through or around the hearing protector and there is an effective seal between the ear plug and the ear canal or between the ear muff and the head.

(5) The proper fitting technique for earplugs and earmuffs must be demonstrated and the technique practised by the worker under close supervision.

For proper fitting of earplugs, the ear should be pulled up and back with the opposite hand, to enlarge and straighten the ear canal. Earplugs should be inserted with clean hands.

For proper fitting of earmuffs, hair and clothing should be pushed back away from the ear and the earmuff cushions placed directly over the ears. The headband must be adjusted for a snug fit according to the manufacturers' instructions.

(6) When ear muffs are used in ways other than those prescribed in the original design i.e. over glasses or long hair, the worker must be informed that the amount of sound attenuation provided by the hearing protector could be reduced.

(7) Hearing protectors must be maintained in the best operative condition. Any alteration in ear muffs or earplugs by the worker (i.e. drilling holes in the earcups, trimming or removing flanges on premolded plugs) will reduce the amount of sound attenuation recommended by the manufacturer, for that particular hearing protector.

(8) The condition and fit of hearing protectors must be examined routinely both in the work area and at the time of the audiometric test. Defective hearing protectors, poorly fitting hearing protectors and improper fitting techniques must be identified and corrected.

Earplugs and ear muff cushions should be kept clean and pliable. When an earplug or ear muff is used daily, it should be replaced at least every six months, and ear muff cushions at least every year.

(9) A worker who demonstrates significant deterioration in hearing on audiometric tests must receive additional counselling with regard to the proper fit, care and use of hearing protectors for both occupational and recreational noise exposure. In addition, the use of hearing protection in the work area, must be monitored.

(10) In noisy work areas where the use of communications head-sets is required in combination with hearing protection, the attenuation characteristics must not be compromised. The volume control should be set to a level adequate for effective communication and the head-set or amplifier must have peak limiting capability. The worker should be counselled that setting the volume control to an excessively loud level will damage hearing.

The use of recreational earphones associated with stereo head-sets, must not be allowed as an alternate form of hearing protection.

(11) In noisy work areas where the wearing of hearing protection is required, clearly visible warning signs as required in Section 10(3) of the Regulation, must be posted.

(12) Records of frequency of use by the worker of hearing protectors, their type and brand name be kept.

THE HEARING PROTECTION PROVISIONS USED BY THE MINISTRY OF LABOUR WILL BE REVIEWED PERIODICALLY AND, IF NECESSARY, REVISED.

APPENDIX La

CODE FOR AUDIOMETRY OF NOISE-EXPOSED WORKERS

Occupational Health Branch
Ontario Ministry of Labour
June 23, 1981

APPENDIX La

CODE FOR AUDIOMETRY OF NOISE-EXPOSED WORKERS

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AUDIOMETRY PROGRAM

1. Purpose

(1) To establish a baseline of hearing sensitivity for each worker exposed to noise at 85 dB(A) or more.

(2) To identify any deterioration in hearing sensitivity among workers exposed to noise at 85 dB(A) or more.

(3) To alert and educate workers whose hearing has deteriorated about the importance of hearing protection.

(4) To identify workers whose hearing requires further investigation and medical treatment.

(5) To enable the employer to monitor the effectiveness of the hearing conservation program.

2. Definitions

Audiometry for the purposes of this code means the determination of unmasked air conduction (AC) hearing levels (HL) for each ear using an electroacoustical instrument called an audiometer.

Audiometric tests consist of baseline and follow up tests. The baseline audiometric test must be carried out upon initiation of the hearing conservation program and thereafter for all new employees prior to noise exposure. The baseline test establishes a worker's hearing sensitivity and serves as a reference with which to compare any changes in hearing that may occur during his working lifetime. Follow up tests must be carried out on an annual basis or more often, when an employee shows a significant change in hearing sensitivity. Audiometric tests must be of sufficiently high quality to ensure

reliable and valid measurements. Reliable audiometry means that on repeated testing of an individual worker using the same standard technique, test findings are consistent within 5 dB. Valid audiometry means that hearing levels measure an individual worker's hearing sensitivity and not the response mode.

The Audiogram is a record of hearing sensitivity where the frequency of a pure tone in Hertz (Hz) is recorded as a function of hearing level (HL) in decibels (dB). The air conduction (AC) hearing levels represent the sensitivity of the entire auditory system including the outer, middle and inner ear. The HL's are recorded graphically or numerically. Graphic recordings must meet the specifications for audiograms as described in the CSA standard Z 107.4 1975 and utilize the symbols: an X for the left ear and an O for the right ear.

The Audiometer is an electroacoustical instrument consisting of a pure tone oscillator, amplifier, attenuator, frequency selector dial, interrupter switch and earphones. The intensity of the pure tone AC stimulus is controlled by the hearing level dial and presentation requires pressing the interrupter switch. The selection of frequency is controlled by manipulating the frequency selector dial.

Audiometric 0 (zero) or 0 dB HL is the reference hearing level to which a worker's hearing threshold levels are compared. Because the ear is not equally sensitive at all frequencies, a weighting system has been built into the audiometer so that all frequencies are equally loud. The minimal sound pressure level (spl) at each frequency corresponds to 0 dB hearing level. When spl is measured, 0 dB HL on the audiometer is different at each frequency.

3. Instrumentation and Test Facilities

There are three types of audiometers suitable for industrial hearing conservation programs. These are manual, automatic, and

microprocessor.

The manual audiometer requires the selection of frequency, intensity and the ear to be tested. A subject is presented with a tone (sound) to which he must respond either by raising his finger or pressing a hand-held button. The intensity of the tone is decreased and increased following a standard threshold measurement technique to obtain the minimum hearing level.

The automatic audiometer presents pulsed tones first to one ear, then the other, across the frequencies 500 Hz to 6000 Hz or 8000 Hz. A subject controls the intensity of the tones by pressing a hand-held button. The hand-held button is pressed when the tone is audible and released when the tone is inaudible.

The microprocessor or computer audiometer presents pure tones in a standard manual technique only automatically. The subject responds by pressing a hand-held switch, which in turn determines the intensity of the next tone. The hearing levels are stored in the unit and then upon completion of the test, printed.

Note: All audiometers must attenuate sound from 0 - 100 dB hearing level. Test frequencies must includer 500, 1000, 2000, 3000, 4000 and 6000 Hz plus 8000 where available.

Audiometers must meet specifications of the CSA Standard Z 107.4 1975 Pure Tone Audiometers for Limited Measurement of Hearing and for Screening.

Audiometric tests must be conducted in a sound booth/room which is located and attenuates background noise according to clause A3.1 and table 2 of the CSA Standard Z 107.4 1975. The maximum allowable spl in dB for threshold measurements with normal operation of the

fan and a TDH 39 earphone mounted in the MX-41/AR cushion must not exceed the following:

Test Frequency	Octave Band Levels
Hz	dB
250	23
500	21.5 - 27.0
1000	29.5
2000	34.5
3000	39.0
4000	42.0
6000	41.0
8000	45.0

Because of the difficulty associated with attenuating low frequency sound the maximum allowable level at 500 Hz has been extended to 27 dB. This compromise was recommended in the Federal Register Vol.46, No.11, Jan.16/81 OSHA - Hearing Conservation Amendment.

Periodic measurements of the background levels in the audiometric booth must be carried out and the results recorded.

4. Personnel

Audiometric tests must be conducted by technicians who according to Appendix A2 of the CSA Standard Z 107.4 1975 are required to complete a training course supervised by someone competent in audiology. According to the Standard, the course should include "in addition to practical training some basic understanding of the anatomy of the ear, physics of sound, limitations and operation of equipment, methods, ethics and legal implications, limits of competence and requirements specific to a particular type of program. A minimum of 20 hours of instruction is recommended to satisfy this requirement."

The industrial audiometric technician should hold a certificate of attendance from a recognized/acceptable training program. The certificate should be renewed every five years.

The industrial audiometric technician should work under supervision and under no circumstances attempt to train others.

5. Calibration Procedures

Calibration of the audiometer involves an annual acoustic and/or exhaustive calibration according to the specifications of the CSA Standard Z 107.4 1975 and a daily calibration by the industrial audiometric technician.

An acoustic calibration requires the measurement of the output of the earphones using a sound level meter with an octave band filter set and an NBS 9A coupler to verify the correct intensity level of a pure tone at a specific frequency. The CSA Standard Z 107.4 1975 provides the reference sound pressure levels for the TDH 39 earphone with an MX-41/AR cushion.

Exhaustive calibration requires measurements as described for an acoustic calibration plus the determinations of: purity of tones, accuracy of tone frequencies, sound from test earphone, sound from the second earphone, unwanted sound and tone switch. This calibration procedure must be carried out in a laboratory setting by either the manufacturer or other qualified agency.

On completion of this calibration, the employer should receive documentation of calibration procedure and the measurements. The audiometer must display a certificate of calibration specifying the date on which this was undertaken and the calibration reference standard.

A daily calibration or listening check requires that the industrial audiometric technician place the earphones over the ears (if the technican's hearing is normal) and determine if thresholds are within ± 5 dB of the previous test. If thresholds deviate more than 5 dB an acoustic calibration is necessary.

The technician should also listen to the tones at normal threshold levels and at loud levels and note if the interrupter switch makes a clicking sound when it is depressed. Cross talk must not be present, i.e. the tone from one earphone is heard in the other earphone. To check for this, the frequency is first set to 1000 Hz; the tone is turned on and the jack pulled out. No tone should be present. Repeat for the other ear.

The panel control of the audiometer must be checked daily to see that:

(i) The audiometer is turned on and given time to warm up.

(ii) The earphones are in the proper jacks i.e. the colour of the earphones corresponds to the control switch on the panel of the audiometer (blue to blue/red to red).

(iii) The earphone plugs are tightly inserted into the jacks.

(iv) The attenuation dial is turned to 0 dB HL.

(v) The frequency selector is placed at the first tone (1000 Hz).

(vi) The interrupter switch is adjusted so that a tone is produced only when the interrupter switch is pressed down.

(vii) The earphone cushions are clean and in good condition.

(viii) The headband tension is sufficient to allow the earphone cushions to be almost touching.

The daily calibration procedure and results must be recorded to facilitate detection of faulty or inaccurate instrumentation.

An audiometer is a precision instrument and requires proper storage and handling.

6. Audiometry

A. **Test Protocol**

Audiometric testing should be undertaken at the beginning of a work shift or during a work shift, if the worker has worn adequate hearing protection. Any significant change in hearing sensitivity must be confirmed by a follow up test within 30 days. The re-test must be carried out only when the worker has been away from noise exposure for 14 hours.The industrial audiometric technician must adhere to the following test protocol prior to initiating the hearing test:

(i) fill out audiogram:

- worker's name
- date of test, time of test
- type of hearing protection
- number of hours hearing protection worn prior to test
- name of industrial audiometric technician
- name of agency, if audiometry contracted
- type and serial number of audiometer and calibration standard
- type of test - baseline, annual, retest

- test reliability -good, fair, poor
- hearing levels
- hearing status: -normal
  -no change
  -significant
  -further investigation/referral required.

(ii) check the worker's ears for excess wax, discharge, earplugs, etc.; note findings.

(iii) seat the worker in the audiometric sound booth so that he/she cannot see either the audiometer or the technician.

(iv) ask the worker if he/she has a cold, ear infection or has noticed any change in hearing; note comments.

(v) ask the worker if he/she hears better in one ear than the other.

(vi) instruct the worker re the hearing test (turn to instructions for Manual, Microprocessor or Automatic Audiometry).

(vii) have the worker remove glasses, if worn.

(viii) place the earphones on the worker pushing the hair back and making sure that the diaphragm of the earphone is over the ear canal and the cord is behind the head. The blue earphone must be placed over the left ear, the red over the right ear.

(ix) proceed with hearing test (turn to Section B - Hearing Threshold Measurement for Manual, Microprocessor and Automatic Audiometry).

(x) record hearing levels and complete audiogram.

The industrial audiometric technician must take care to avoid errors related to test protocol. The most common errors are:

(i) Taking too much time to complete a hearing test, i.e., more than 8 minutes.

(ii) placing the earphones improperly and testing the wrong ear.

(iii) presenting the tone for longer than 1-2 seconds.

(iv) forgetting to recheck 1000 Hz.

(v) presenting the tones in a rhythmical pattern.

(vi) talking during the test procedure.

B. **Hearing Threshold Measurement**

There are two methods for obtaining hearing threshold using pure tone air conduction audiometry, the method of limits and the method of adjustment.

In the method of limits, the tester controls the stimulus intensity and the frequency and the subject simply responds to the stimulus. When the stimulus is gradually increased in intensity on every presentation until the subject responds, the procedure is called the ascending method of limits. When the stimulus is gradually decreased in intensity on every presentation until the subject no longer responds, the procedure is called the descending method of limits.

In industrial settings the ascending and descending method of limits have been adapted for use with the manual and microprocessor

audiometers.

In Manual and Microprocessor Audiometry, the industrial audiometric technician should proceed as follows:

Manual Audiometry

Method 1.

(i) Instruct the worker: "You are going to hear a series of tones (sounds) which will become gradually quieter. As soon as you hear the tone raise your finger and keep it raised as long as you hear it."

(ii) Start with the better ear or the right ear.

(iii) Set the frequency at 1000 Hz and the attenuator at 40 dB hearing threshold level.

(iv) Present the tone for one second, wait for the worker to respond.

(v) If the subject responds, decrease the intensity in 10 dB steps until the subject no longer responds, then increase in 5 dB steps to determine hearing threshold.

(vi) Repeat this procedure until the subjet has responded to the tone at least twice on an ascending trial at a specific threshold.

(vii) If the subject does not respond at 40 dB ascend to 60 dB - 70 dB - 80 dB - 90 dB etc. until there is a response. Use the above bracketing procedure "down 10 dB, up 5 dB" to determine threshold.

(viii) If the worker does not respond to the limit of the audiometer, record no response (NR).

(ix) Test 1000, 2000, 3000, 4000, 6000, 8000, recheck 1000, then to 500 Hz. Repeat for the other ear. The 1000 Hz recheck should agree within ± 5 dB.

(x) Record the hearing level at each frequency on the audiogram.

Method 2.

(i) Instruct the worker: same as above.

(ii) Same as above.

(iii) Set the frequency dial to 1000 Hz.

(iv) Present the tone and slowly roll the hearing level dial from 0 dB until the worker responds.

(v) Release the tone; present the tone to confirm the response. Use the bracketing procedure "down 10 dB, up 5 dB" to determine threshold.

(vi) Same as (viii-ix) above.

Microprocessor Audiometry

(i) Instruct the worker: "You are going to hear a series of beeping tones (sounds) which will become gradually quieter. Press the button whenever you hear the tones."

(ii) Enter date and subject identification.

(iii) Select ear to be tested first.

(iv) Press ENTER/TEST switch.

(v) The audiometer begins at 40 dB at 1000 Hz using the manual method 1 to achieve threshold. After 1000 Hz, 500 Hz is tested, then 1000 Hz is retested. If the hearing threshold levels are within ± 5 dB, the audiometer automatically proceeds to the other frequencies - 2000, 3000, 4000, 6000 and 8000.

(vi) Hearing levels are automatically recorded by the printer.

In the Method of Adjustment, the subject controls the stimulus intensity and frequency. The subject is given a hand-held button/switch to control a motor driven attenuator and then instructed to manipulate this so that the tone alternates between audible and inaudible. The mean of the two values is the hearing threshold.

In industrial settings the method of adjustment has been adapted for use with the automatic audiometer.

In Automatic Audiometry, the industrial audiometric technician should proceed as follows:

Automatic Audiometry

(i) Instruct the worker: "You are going to hear a series of beeping tones (sounds). Each time you hear the tone press the button and hold it down until the tone goes away. Press when you hear; release when you don't."

(ii) Depress the start switch.

(iii) Press hold or trial switch. Leave switch down until the subject averages 10 excursions. If excursions are abnormally large or small reinstruct.

(iv) Begin the test by releasing trial or hold switch.

(v) The technician should watch for abnormalities in test performance. The spread between excursions should be within 15 dB and there should be at least 5 excursions per frequency.

(vi) The mid-delay switch should be set to allow a pause between testing the ears.

(vii) If excursions are less than 15 dB, determine the hearing threshold by averaging the peaks and valleys of the excursions across the frequency band. If excursions are greater than 15 dB in the low frequencies, average the peaks and add 5 dB. If excursions are greater than 15 dB in the higher frequencies average the valleys and subtract 10 dB. Where excursions are greater than 15 dB in either low or high frequencies, the audiogram should be rated poor to fair.

(viii) Record the hearing levels for each frequency band on the audiogram.

While pure tone air conduction audiometry reflects any dysfunction in the auditory system - outer, middle or inner ear, it cannot differentiate the type of hearing loss. To diagnose or confirm a noise induced hearing loss, an otological and audiological investigation is required. Furthermore, in some workers where symptoms associated with noise induced hearing loss such as tinnitus or recruitment are present, further investigation may be necessary to establish correct hearing levels.

These symptoms can interfere with a worker's ability to perform reliably in an industrial hearing test.

APPENDIX Lb

CODE FOR AUDIOMETRY OF NOISE-EXPOSED WORKERS

MINISTRY OF LABOUR
OCCUPATIONAL HEALTH AND SAFETY DIVISION
November 23, 1981

APPENDIX Lb

CODE FOR AUDIOMETRY OF NOISE-EXPOSED WORKERS

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AUDIOMETRY PROGRAM

1. Purpose

(1) To establish baseline hearing levels for each worker included in the hearing conservation program as required in section 7(1) of the Regulation.

(2) To identify any deterioration in hearing levels among workers included in the hearing conservation program as required in section 7(1) of the Regulation.

(3) To identify workers whose hearing requires further investigation.

(4) To alert and educate workers whose hearing has deteriorated about the importance of hearing protection.

(5) To monitor the effectiveness of hearing protection.

(6) To monitor the effectiveness of the hearing conservation program.

2. Definitions

(a) The audiometer is an electroacoustical device which provides pure tones of selected frequencies of calibrated outputs and consists of a pure tone oscillator, amplifier, attenuator, frequency selector dial, interrupter switch and earphones. The audiometer must meet the specifications as described in the CSA Standard Z107.4-1975 (Amended 1980) "Pure Tone Audiometers for Limited Measurement of Hearing and for Screening".

(b) Audiometry for the purposes of this code means the determination of unmasked pure tone air conduction hearing threshold levels at 500, 1000, 2000, 3000, 4000 and 6000 Hertz (Hz).

(c) The audiogram is a chart, graph or table resulting from an audiometric test showing the hearing threshold levels of a worker as a function of frequency. Graphic recordings must meet the specifications for audiograms as described in the CSA Standard Z107.4-1975 (Amended 1980) and utilize the symbols: O for the right ear and X for the left ear.

(d) Threshold of audibility is the minimum intensity of a signal capable of evoking an auditory sensation for a specified number of trials. The characteristics of the signal, the manner in which it is presented and the point at which the intensity is measured are specified.

(e) Hearing level (hearing threshold level, HL) is the number of dB by which the threshold of audibility for a workers' ears exceeds the standard reference threshold.

(f) Audiometric zero is the reference threshold level specified in the CSA Standard Z107.4-1975 (Amended 1980) to which a worker's hearing is compared.

(g) Decibel (dB) is a dimensionless unit of sound pressure level.

(h) Sound pressure level (SPL) for purposes of this code is the rms sound pressure level developed by the audiometer earphone in a U.S. National Bureau of Standards (NBS) 9-A coupler as shown in the CSA Standard Z107.4-1975 (Amended 1980).

(i) Hertz (Hz) is a unit of frequency in cycles per second.

3. Instrumentation and Test Facilities

All Audiometers must meet the specifications of the CSA Standard Z107.4-1975 (Amended 1980) "Pure Tone Audiometers for Limited Measurement of Hearing and for Screening".

They must attenuate sound from 0 to 90 dB hearing level and include at least the following test frequencies: 500, 1000, 2000, 3000, 4000 and 6000 Hz.

Three types of audiometers are suitable for industrial hearing conservation programs. They are manual, automatic, and computer controlled.

The manual audiometer is a pure tone audiometer in which the signal presentations, frequency and recording of results are performed manually.

The automatic audiometer and computer-controlled audiometer are pure tone audiometers in which the signal presentations, hearing level variation, frequency selection or frequency variation and recording of subject responses are implemented automatically.

The programming and operation of the automatic and computer-controlled audiometer must be such that they give results consistent with that of manual audiometry.

Audiometric tests must be conducted in sound-proof booths which permit testing to 0 dB hearing level (standards for screening audiometry do not satisfy this requirement) and meet the following criteria:

(a) inside dimensions of at least 1m x 1m x 2m;

(b) ventilation of at least 15 m^3/h; and

(c) location away from waiting rooms, corridors, elevators, furnaces, or boiler rooms and other noise or vibration sources.

Audiometric tests must be conducted in sound-proof booths which are located and attenuate background noise according to the CSA Standard Z107.4-1975 (Amended 1980). The maximum allowable sound pressure level (SPL) in dB for threshold measurements with normal operation of the fan and a Telephonics TDH 39 earphone mounted in the MX-41/AR cushion, specified in the CSA standard, must not exceed the levels in the standard with the exception of the following:

Test Tone Frequency (Hz)	Octave Band Levels
250	40 dB
500	30 dB

Periodic measurements of the background levels in the sound-proof booth must be carried out at least annually according to the procedures described in section 3(4)(e) in the Code for Noise Measurement dated the 23rd day of November, 1981 and the results recorded.

4. **Personnel**

Audiometric tests must be conducted by a registered audiologist or an industrial audiometric technician.

Industrial audiometric technicians must have completed a training course supervised by someone competent in audiology. As stated in CSA Standard Z107.4-1975 (Amended 1980), any such course should include:

"in addition to practical training, some basic understanding of the anatomy of the ear, physics of sound, limitations and operation of equipment, methods, ethics and legal implications, limits of competence and requirements specific to a particular type of program". A minimum of 20 hours of instruction is recommended, to satisfy the requirements of the CSA Standard Z107.4-1975 (Amended 1980).

The course should also provide instruction in the selection, fit, care and use of hearing protection.

The industrial audiometric technician must hold a certificate of attendance from an acceptable course and the certificate should be renewed every five years.

Where delegated to do so, the industrial audiometric technician or audiologist may discuss the results of the audiometric test with the worker.

5. Calibration Procedures

Calibration of the audiometer must include an annual acoustic calibration and a biennial, exhaustive calibration carried out according to the specifications of the CSA Standard Z107.4-1975 (Amended 1980).

An acoustic calibration requires the measurement of the output of the earphones using a sound level meter with an octave band filter set and an NBS 9A coupler according to the procedures described in the Code for Noise Measurement. The accuracy of the calibrating equipment shall be sufficient to determine that the audiometer is within the tolerances permitted by the CSA Standard Z107.4-1975 (Amended 1980).

Reference threshold levels in dB for the Telephonics TDH-39 earphone with an MX41/AR cushion are specified in the CSA Standard Z107.4-1975 (Amended 1980).

Reference threshold levels in dB for the Telephonics TDH-49 earphone are specified below:

Frequency in Hz	Reference Threshold Level in dB
500	13.5
1000	7.5
2000	11
3000	9.5
4000	10.5
6000	13.5

Earphones must not be interchanged without an acoustic calibration.

An exhaustive calibration requires measurement as described in the CSA Standard Z107.4-1975 (Amended 1980) for an acoustic calibration plus the determination of: purity of tones, accuracy of tone frequencies, sound from test earphone, sound from the second earphone, unwanted sound and tone switch. This calibration procedure must be carried out in a laboratory setting, by either the manufacturer or other qualified agency.

The employer must obtain and keep documentation of the calibration schedule and the actual measurements. The audiometer must display a certificate of calibration specifying the date on which this was undertaken and the calibration reference standard.

In addition to an acoustic and exhaustive calibration, a daily listening check and a monthly biologic calibration should be carried out by the industrial audiometric technician.

A daily listening check includes:

(a) listening to the tones at normal threshold levels and at loud levels and noting if the interrupter switch makes a clicking sound when it is depressed;

(b) checking for cross talk, i.e. the tone from one earphone is heard in the other earphone; by setting the frequency selector dial to 1000 Hz, turning the tone on, and pulling out the jack (no tone should be present: repeat procedure for the other ear); and

(c) recording the results.

A monthly biologic calibration includes:

(a) placing the earphones over the ears (if the technicians's hearing is normal) and determining if hearing levels are within $\pm$ 5 dB of the previous test. When hearing levels deviate by more than 10 dB an acoustic calibration is necessary; and

(b) recording the results.

6. Audiometry

(1) Types of Hearing Tests

Audiometric tests must consist of baseline and follow-up hearing tests. These must be scheduled at the beginning of a work shift or during a work shift, if the worker has worn appropriate hearing protection as defined under section 4, in the Code for Hearing Protection of Noise-Exposed Workers.

The baseline test establishes the hearing level of a worker prior to noise exposure and serves as a reference with which to compare any changes in hearing that may occur during his working lifetime. The baseline test must be obtained for all workers included in the hearing conservation program and for all new employees prior to noise exposure.

Follow-up tests must be carried out at least biennially or more often if a worker shows a significant change in hearing. Any significant change in hearing must be confirmed by a retest within 60 days. The retest must be carried out only when the worker has been away from any occupational noise exposure for at least 14 hours.

Pure tone air conduction audiometry is only an identification procedure and must not be used to differentiate type or degree of hearing loss. To properly diagnose any hearing loss and in particular noise induced hearing loss, a full otological and audiological investigation is required.

(2) **Test Protocol**

The industrial audiometric technician must adhere to the following test protocol.

(a) (i) The audiometer must be turned on and given time to warm up.

(ii) The earphones must be in the proper jacks i.e. the colour of the earphones must correspond to the control switch on the panel of the audiometer (blue to blue/red to red).

(iii) The earphone plugs must be tightly inserted into the jacks.

(iv) The attenuation dial must be turned to 0 dB HL.

(v) The frequency selector must be placed at the first tone.

(vi) The interrupter switch must be adjusted so that a tone is only produced when the interrupter switch is pressed down.

(vii) The earphone cushions must be kept clean and in good condition.

(viii) The headband tension must be sufficient to allow the earphone cushions to be almost touching when held free.

(b) The audiogram must be filled out and should include:

(i) name in full of the worker;
(ii) date of test, time of test;
(iii) type of hearing protection;
(iv) number of hours hearing protection worn prior to test;
(v) name of industrial audiometric technician;
(vi) name of agency, if audiometry contracted;
(vii) type and serial number of audiometer, calibration date and reference standard; and
(viii) type of test - baseline, follow-up, retest.

(c) The worker's ears must be checked for excess wax, discharge, earplugs, etc.; note findings.

(d) The worker must be seated in the audiometric sound proof booth so that he cannot see either the audiometer or the industrial audiometric technician.

(e) The worker must be asked if he has a cold, or an ear infection, and if he has noticed any change in hearing; note comments.

(f) The worker must be asked if he hears better in one ear than the other.

(g) The worker must be instructed (see section 6(3), Hearing Threshold Measurement, instructions for manual, automatic or computer-controlled audiometry).

(h) The worker must remove glasses, if worn.

(i) The earphones must be placed to ensure that there is no loose hair under the earphones, that the earphones are over the ear canals and the cord is behind the head. The blue earphone must be placed over the left ear, the red earphone over the right ear.

(j) The hearing test must be obtained using one of the techniques described in section 6(3) for Hearing Threshold Measurement using manual, automatic or computer-controlled audiometry.

(k) Hearing levels must be recorded and the audiogram completed.

(l) Care must be taken to avoid:

(i) taking too much time to complete the hearing

test i.e. more than 8 minutes;

(ii) placing the earphones improperly and/or testing the wrong ear;

(iii) presenting the tone for longer than 1-2 seconds;

(iv) presenting the tones in a rhythmical pattern; and

(v) talking during the test procedure.

(m) Results must be recorded to include:

(i) test reliability - good, fair, poor;

(ii) hearing levels (see Section 6(3), Hearing Threshold Measurement); and

(iii) hearing status:

Normal (average hearing threshold level of 25 dB across 500, 1000, 2000, and 3000 Hz);

No Change (hearing threshold levels within ± 5 dB of previous audiogram);

Significant Threshold Shift (a difference of 20 dB at 3000 or 4000 Hz compared with either the baseline or previous audiogram).

(3) **Hearing Threshold Measurement**

(a) **Manual Audiometry**

For manual audiometry, the industrial audiometric

technician must proceed as follows.

Method 1.

(i) Instruct the worker: "You are going to hear a series of tones (sounds) which will become gradually quieter. As soon as you hear the tone raise your finger (press the button) and keep it raised (keep it pressed) as long as you hear it."

(ii) Start with the better ear or the right ear first.

(iii) Set the frequency selector dial to 1000 Hz and turn the hearing level dial to 40 dB HL.

(iv) Present the tone for one to two seconds; wait for the worker to respond. If the worker does not respond at 40 dB HL ascend to 50, 60, 70 dB HL etc. until there is a response.

(v) When the subject responds, decrease the intensity in 10 dB steps until the subject no longer responds, then increase in 5 dB steps to determine hearing threshold level.

(vi) Repeat this procedure (down 10 dB, up 5 dB) until the subject has responded to the tone at least twice on an ascending trial at a specific hearing level.

(vii) If the worker does not respond to the limit of the audiometer, record no response (NR) or use the symbols O for the right ear and X for the left ear.

(viii) Present test frequencies in the following order: 1000, 2000, 3000, 4000, 6000, (8000, if available), 1000 (recheck), and then 500 Hz. The 1000 Hz recheck should agree within ± 5 dB; if it does not, re-instruct the worker and repeat the test.

(ix) Record the hearing level at each frequency on the audiogram.

(x) Repeat the entire procedure for the other ear.

Method 2.

(i) Instruct the worker (as above).

(ii) Start with the better ear or right ear (as above).

(iii) Set the frequency selector dial to 1000 Hz.

(iv) Present the tone at 0 dB hearing level, keeping the interrupter switch depressed, and gradually turning the hearing level dial until the worker responds.

(v) Release the tone; present the tone again to confirm the response. Proceed with steps (v) to (x) in Method 1.

(b) **Computer-Controlled Audiometry**

For computer-controlled audiometry, the industrial audiometric technician must proceed as follows:

(i) Instruct the worker: "You are going to hear a series of beeping tones (sounds) which will become gradually quieter. Press the button whenever you hear the tones".

(ii) Familiarize the worker with the test protocol by following the instructions provided by the manufacturer.

(iii) Enter any data as directed in the instructions provided by the manufacturer and proceed accordingly.

(iv) Observe and monitor the test performance of the worker throughout the test.

(c) **Automatic Audiometry**

(i) Instruct the worker: "You are going to hear a series of beeping tones (sounds). Each time you hear the tone press the button and hold it down until the tone goes away. Press when you hear; release when you don't".

(ii) Familarize the worker with the test protocol for the trial by following the instructions provided by the manufacturer.

(iii) Start the test by releasing the trial mode.

(iv) Observe and monitor the performance of the worker throughout the test.

(v) An automatic recording must be considered

unreliable if excursions are greater than 15 dB or there are less than six excursions per frequency. If excursions are less than 15 dB, determine the hearing threshold level by averaging the peaks and valleys of the excursions across the frequency band. If excursions are greater than 15 dB in the low frequencies, average the peaks and add 5 dB. If excursions are greater than 15 dB in the higher frequencies average the valleys and subtract 10 dB.

(vi) Record the hearing threshold levels for each frequency band on the audiogram.

APPENDIX Lc

CODE FOR AUDIOMETRY OF NOISE-EXPOSED WORKERS

MINISTRY OF LABOUR
OCCUPATIONAL HEALTH AND SAFETY DIVISION
November 5, 1982

APPENDIX Lc

CODE FOR AUDIOMETRY OF NOISE-EXPOSED WORKERS

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AUDIOMETRY PROGRAM

1. Purpose

(1) To establish baseline hearing levels for each worker included in the hearing conservation program as required in section 12 of the Regulation.

(2) To identify any deterioration in hearing levels among workers included in the hearing conservation program as required in section 12 of the Regulation.

(3) To identify workers whose hearing requires further investigation.

(4) To alert and educate workers whose hearing has deteriorated about the importance of hearing protection.

(5) To monitor the effectiveness of hearing protection.

(6) To monitor the effectiveness of the hearing conservation program.

2. Definitions

(a) The audiometer is an electroacoustic instrument which provides pure tones of specified discrete frequencies of calibrated sound pressure levels and consists of a pure tone oscillator, amplifier, attenuator, frequency selector dial, interrupter switch and earphones. The audiometer must meet the specifications as described in the CSA Standard Z107.4-1975 (Amended 1980) "Pure Tone Audiometers for Limited Measurement of Hearing and for Screening".

(b) The manual audiometer is a pure tone audiometer in which the signal presentations, frequency, hearing level selection, and

recording of results are performed manually.

(c) The self-recording/automatic audiometer is a pure tone audiometer in which the signal presentation, hearing level variation, frequency selection or variation and recording of subject responses are implemented automatically.

(d) Audiometry for the purposes of this code means the determination of hearing threshold levels for pure tones by air conduction under monaural listening conditions.

(e) The audiogram is a record, in graphical or tabular form resulting from an audiometric test determined under specified conditions and by a specified method, showing hearing threshold levels as a function of frequency. Graphic recordings must meet the specifications for audiograms as described in the CSA Standard Z107.4-1975 (Amended 1980) and utilize the symbols: X for the left ear and O for the right ear.

(f) Threshold of audibility is the minimum sound presure level of a signal capable of evoking an auditory sensation for a specified number of trials. The characteristics of the signal, the manner in which it is presented and the point at which it is measured are specified.

(g) Hearing level (hearing threshold level, HL) for a given ear at a specified frequency, is the number of dB by which the threshold of audibility for a worker, exceeds the standard reference zero.

(h) Reference/Audiometric zero is the sound pressure level measured in an acoustic coupler (or artificial ear) and specified in the CSA Standard Z107.4-1975 (Amended 1980) to which a worker's hearing is compared.

(i) Decibel (dB) is a dimensionless unit of sound pressure level.

(j) Sound pressure level (SPL) for purposes of this code is the rms sound pressure level developed by the audiometer earphone in a U.S. National Bureau of Standards (NBS) 9-A coupler as specified in the CSA Standard Z107.4-1975 (Amended 1980).

(k) Hertz (Hz) is a unit of frequency in cycles per second.

3. **Instruments**

All Audiometers must meet the specifications of the CSA Standard Z107.4-1975 (Amended 1980) "Pure Tone Audiometers for Limited Measurement of Hearing and for Screening".

They must attenuate sound from -10 dB to +90 dB hearing level and include at least the following test frequencies: 500, 1000, 2000, 3000, 4000 and 6000 Hz.

Three types of audiometers are suitable for use in industrial hearing conservation programs. They are manual, self-recording or automatic, and computer-controlled audiometers.

Self-recording audiometers must also meet the following requirements:

(1) pulse tone on-time of at least 200 m. secs.,

(2) slewing rate for the attenuator of 5 dB per second except at the beginning of each new frequency, until the second response.

The programming and operation of the self-recording and computer-controlled audiometer must be such, that they will give results consistent with that of manual audiometry.

4. Facilities

Audiometric tests must be conducted in sound-proof booths which permit testing to 0 dB hearing level (standards for screening audiometry do not satisfy this requirement) and meet the following criteria:

(a) inside dimensions of at least 1m x 1m x 2m;

(b) ventilation of at least 15 m^3/h; and

(c) location away from waiting rooms, corridors, elevators, furnaces, or boiler rooms and other noise or vibration sources.

Audiometric tests must be conducted in sound-proof booths which are located and attenuate background noise according to the CSA Standard Z107.4-1975 (Amended 1980). The maximum allowable sound pressure level (SPL) in dB for threshold measurements with normal operation of the fan and a Telephonics TDH 39 earphone mounted in the MX-41/AR cushion, must not exceed the standard with the exception of 250 Hz and 500 Hz:

Test Tone Frequency (Hz)	Octave Band Levels
250	40 dB
500	30 dB
1000	29.5 dB
2000	34.5 dB
4000	42 dB
8000	45 dB

Where these levels cannot be achieved further acoustic treatment of the test environment is required.

Periodic measurements of the background levels in the sound-proof booth must be carried out at least annually according to the procedures described in section 3 in the Code for Noise Measurement and the results recorded.

5. Personnel

Audiometric tests must be conducted by a registered audiologist or an industrial audiometric technician.

Industrial audiometric technicians must have completed a training course supervised by someone competent in audiology.

As specified in the CSA Standard Z107.41975 (Amended 1980) training courses should include:

"practical training, some basic understanding of the anatomy of the ear, physics of sound, limitations and operation of equipment, methods, ethics and legal implications, limits of competence and requirements specific to a particular type of program". A minimum of 20 hours of instruction is recommended, to satisfy these requirements.

In addition, the training course should also provide instruction in the selection, fit, care and use of hearing protection.

The industrial audiometric technician must hold a certificate of attendance from an acceptable training course and the certificate should be renewed every five years.

Where delegated to do so, an audiologist or the industrial audiometric technician may discuss the results of audiometric tests with the worker.

6. Calibration and Maintenance Procedures

Calibration of the audiometer must include a biennial exhaustive calibration and an annual acoustic calibration carried out according to the specifications of the CSA Standard Z107.4-1975 (Amended 1980).

An acoustic calibration requires the measurement of the output of the earphones using a sound level meter with an octave band filter set and an NBS 9A coupler according to the procedures described in Section 3 of the Code for Noise Measurement. Acoustic calibration measurements must be taken at 70 dB HL at .5, 1, 2, 3, 4, 6 KHz, then at 1 KHz in decreasing steps of 10 dB from 70 dB HL to 10 dB HL. The accuracy of the calibrating equipment shall be sufficient to determine that the audiometer is within the tolerances (3 dB at 500 - 3000 Hz, 4 dB at 4000 Hz and 5 dB at 6000 Hz) permitted by the CSA Standard Z107.4-1975 (Amended 1980).

Where measurements exceed these tolerances an exhaustive calibration is required.

Reference threshold levels in dB for the Telephonics TDH-39 earphone with an MX41/AR cushion are specified in the CSA Standard Z107.4-1975 (Amended 1980).

Reference threshold levels in dB for the Telephonics TDH-49 earphone are specified below:

Frequency in Hz	Reference Threshold Level in dB
500	13.5
1000	7.5
2000	11
3000	9.5
4000	10.5
6000	13.5

Earphones must not be interchanged without an acoustic calibration.

An exhaustive calibration requires measurement as described in the CSA Standard Z107.4-1975 (Amended 1980) for an acoustic calibration plus the determination of: purity of tones, accuracy of tone frequencies, sound from test earphone, sound from the second earphone, unwanted sound and tone switch. This calibration procedure must be carried out in a laboratory setting, by either the manufacturer or other qualified agency.

The employer must obtain and keep documentation of the calibration schedule and the actual measurements. The audiometer must display a certificate of calibration specifying the date on which this was undertaken and the calibration reference standard.

In addition to an acoustic and exhaustive calibration, a daily listening check and a monthly subjective calibration should be carried out by an audiologist or the industrial audiometric technician.

A listening check includes listening for distortions, attenuator and tone-switch, transients and other unwanted sounds from the audiometer. If unwanted sounds are heard, the audiometer must be withdrawn and serviced.

A subjective calibration includes testing the hearing of a person with known stable normal hearing and determining if hearing levels are within $\pm$ 5 dB of the previous test. Where hearing levels deviate by more than 10 dB an acoustic calibration is necessary.

The employer must make available complete calibration records.

7. Audiometry

(1) Types of Hearing Tests

Audiometric tests must consist of baseline and follow-up hearing tests.

Baseline hearing tests must be scheduled at the beginning of a work shift prior to noise exposure.

The baseline hearing tests establishe the hearing level of a worker prior to noise exposure and serves as a reference with which to compare any changes in hearing that may occur during his working lifetime. The baseline test must be obtained for all workers included in the hearing conservation program and for all new employees prior to noise exposure.

Follow-up hearing tests may be scheduled at the beginning or during a work shift, if the worker has worn appropriate hearing protection as defined in the Code for Hearing Protection.

Follow-up hearing tests must be carried out at least biennially or more often if a worker shows a significant change in hearing. Any significant change in hearing must be confirmed by a retest within 60 days. The retest must be carried out only when the worker has been away from any occupational noise exposure for at least 14 hours.

The definition of significant change in hearing is critical to the effective operation of the Hearing Conservation Program. Generally speaking, those workers who show significant changes in hearing as defined by a physician or an audiologist, should be monitored more closely using stricter criteria.

Pure tone air conduction audiometry is only an identification procedure and must not be used to differentiate type or degree of hearing loss. To properly diagnose any hearing loss and in particular noise induced hearing loss, a full otological and audiological investigation is required.

(2) **Test Protocol**

The industrial audiometric technician must adhere to the following test protocol.

(a) (i) The audiometer must be turned on and given time to warm up.

(ii) The earphones must be in the proper jacks i.e. the colour of the earphones must correspond to the control switch on the panel of the audiometer (blue to blue/red to red).

(iii) The earphone plugs must be tightly inserted into the jacks.

(iv) The attenuation dial must be turned to 0 dB HL.

(v) The frequency selector must be placed at the first tone.

(vi) The interrupter switch must be adjusted so that a tone is only produced when the interrupter switch is pressed down.

(vii) The earphone cushions must be kept clean and in good condition.

(viii) The headband tension must be sufficient to allow the earphone cushions to be almost touching when held free.

(b) The audiogram must be filled out and should include:

(i) name in full of the worker;
(ii) date of test, time of test;
(iii) type of hearing protection;
(iv) number of hours hearing protection worn prior to test;
(v) name of industrial audiometric technician;
(vi) name of agency, if audiometry contracted;
(vii) type and serial number of audiometer, calibration date and reference standard; and
(viii) type of test - baseline, follow-up, retest.

(c) The worker's ears must be checked for excess wax, discharge, earplugs, etc.; note findings.

(d) The worker must be seated in the audiometric sound-proof booth so that he cannot see either the audiometer or the industrial audiometric technician.

(e) The worker must be asked if he has a cold, or an ear infection, and if he has noticed any change in hearing; note comments.

(f) The worker must be asked if he hears better in one ear than the other..

(g) The worker must be instructed (see section 7(3), Hearing Threshold Measurement, Instructions for Manual, Self Recording or Computer-Controlled Audiometry).

(h) The worker must remove glasses, if worn.

(i) The earphones must be placed to ensure that there is no loose hair under the earphones, that the earphones are over the ear canals and the cord is behind the head. The blue earphone must be placed over the left ear, the red earphone over the right ear.

(j) The hearing test must be obtained using one of the techniques described in section 6(3) for Hearing Threshold Measurement using Manual, Self-Recording or Computer-Controlled Audiometry.

(k) Hearing levels must be recorded and the audiogram completed.

(l) Care must be taken to avoid:

(i) taking too much time to complete the hearing test i.e. more than 8 minutes;

(ii) placing the earphones improperly and/or testing the wrong ear;

(iii) presenting the tone for longer than 1-2 seconds;

(iv) presenting the tones in a rhythmical pattern; and

(v) talking during the test procedure.

(m) Results must be recorded to include:

(i) test reliability - good, fair, poor;

(ii) hearing levels (see Section 6(3), Hearing Threshold Measurement); and

(iii) hearing status:

eg. Normal (average hearing threshold level of 25 dB or less across 500, 1000, 2000, and 3000 Hz);

eg. No Change (hearing threshold levels within ± 5 dB of previous audiogram);

eg. Significant Threshold Shift (a difference of 15 dB at 3000 or 4000 Hz compared with either the baseline or previous audiogram).

(3) **Hearing Threshold Measurement**

(a) **Manual Audiometry**

For manual audiometry, the industrial audiometric technician must proceed as follows.

Method 1. Bracketing Technique

(i) Instruct the worker: "You are going to hear a series of tones (sounds) which will become gradually quieter. As soon as you hear the tone raise your finger (press the button) and keep it raised (keep it pressed) as long as you hear it."

(ii) Start with the better ear or the right ear first.

(iii) Set the frequency selector dial to 1000 Hz and turn the hearing level dial to 40 dB HL.

(iv) Present the tone for one to two seconds; wait for the worker to respond. If the worker does not respond at 40 dB HL ascend to 50, 60, 70 dB HL etc. until there is a response.

(v) When the subject responds, decrease the intensity in 10 dB steps until the subject no longer responds, then increase in 5 dB steps to determine hearing threshold level.

(vi) Repeat this procedure (down 10 dB, up 5 dB) until the subject has responded to the tone at least twice on an ascending trial at a specific hearing level.

(vii) If the worker does not respond to the limit of the audiometer, record no response (NR) or use the symbols ↓O for the right ear and X↓ for the left ear.

(viii) Present test frequencies in the following order: 1000, 2000, 3000, 4000, 6000, (8000, if available), 1000 (recheck), and then 500 Hz. The 1000 Hz recheck should agree within ± 5 dB; if it does not, re-instruct the worker and repeat the test.

(ix) Record the hearing level at each frequency on the audiogram.

(x) Repeat the entire procedure for the other ear.

Method 2. Ascending Technique

(i) Instruct the worker (as above).

(ii) Start with the better ear or right ear (as above).

(iii) Set the frequency selector dial to 1000 Hz.

(iv) Present the tone at 0 dB hearing level, keeping the interrupter switch depressed, and gradually turning the hearing level dial until the worker responds.

(v) Release the tone; present the tone again to confirm the response. Proceed with steps (v) to (x) in Method 1.

(b) **Computer-Controlled Audiometry**

For computer-controlled audiometry, the industrial audiometric technician must proceed as follows:

(i) Instruct the worker: "You are going to hear a series of beeping tones (sounds) which will become gradually quieter. Press the button whenever you hear the tones".

(ii) Familiarize the worker with the test protocol by following the instructions provided by the manufacturer.

(iii) Enter any data as directed in the instructions provided by the manufacturer and proceed accordingly.

(iv) Observe and monitor the test performance of the worker throughout the test.

(c) **Self-Recording Audiometry**

For self-recording audiometry, the industrial audiometric technician must proceed as follows:

(i) Instruct the worker: "You are going to hear a series of beeping tones (sounds). Each time you hear the tone press the button and hold it down until the tone goes away. Press when you hear; release when you don't".

(ii) Familarize the worker with the test protocol for the trial by following the instructions provided by the manufacturer.

(iii) Start the test by releasing the trial mode.

(iv) Observe and monitor the performance of the worker throughout the test.

(v) An automatic recording must be considered unreliable if excursions are greater than 15 dB or there are less than six excursions per frequency. If excursions are less than 15 dB, determine the hearing threshold level by averaging the peaks and valleys of the excursions across the frequency band. If excursions are greater than 15 dB in the low frequencies, average the peaks and add 5 dB. If excursions are greater than 15 dB in the higher frequencies average the valleys and subtract 10 dB.

(vi) Record the hearing threshold levels for each frequency band on the audiogram.

THE AUDIOMETRY PROVISIONS USED BY THE MINISTRY OF LABOUR WILL BE REVIEWED PERIODICALLY AND, IF NECESSARY, REVISED.

APPENDIX Ma

CODE FOR NOISE MEASUREMENT

Occupational Health Branch
Ontario Ministry of Labour
June 23, 1981

APPENDIX Ma

CODE FOR NOISE MEASUREMENT

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NOISE MEASUREMENT

1. Purpose of the Code

The basic objective of this Code is to establish uniform procedures for obtaining sound level data, peak sound pressure level data, and sound exposure data for the purposes of the noise regulation and associated Codes (Code for Hearing Protection; Code for Audiometry).

2. Purpose of Noise Measurements

(a) To identify work areas and noise sources with excessive noise levels.

(b) To determine which workers should be individually monitored for noise exposure.

(c) To evaluate and document the personal exposure of a worker to noise.

(d) To determine the need for the establishment of a hearing conservation program.

(e) To identify workers who should be given periodic otoscopic examinations and audiometric tests.

(f) To identify workers who require personal hearing protection, and determine the amount of attenuation that hearing protectors must provide.

(g) To determine the need for and type of control measures, including engineering and work practice controls, and to monitor the effectiveness of control measures.

3. Instrumentation for Noise Measurements

(1) Sound Level Meter (SLM)

A sound level meter consisting of a microphone, amplifier with a calibrated attenuator, frequency weighting networks, indicator meter, and an optional electrical output connection determines a frequency weighted sound level in decibels (dB). A sound level meter used to obtain sound level measurements required by the noise regulation must be of Type 1 or Type 2 (as appropriate - see section 4 below), and must meet the performance requirements of either the Canadian Standards Association (CSA) Standard Z107.1-1973 (ANSI S1.4-1971 (R1976)) "Specification for Sound Level Meters" or of the International Electrotechnical Commission (IEC) Standard IEC 651-1979 "Sound Level Meters" (N.B. The standard ANSI S1.4-1971 (R1976) is being revised).

As discussed in sections 4 and 6, A-weighted sound level measurements obtained with a sound level meter may be used to determine the various measures of a worker's exposure, including the equivalent continuous sound level Leq (40) that is required by the noise regulation.

(2) Auxiliary Equipment for Sound Level Meters

A sound level meter used with auxiliary equipment such as microphone cable, microphone windscreen, headphones, analyzers, calibrator, external filters, and tape recorders must meet the requirements of CSA Z107.1-1973 or IEC 651-1979.

Octave and third octave band filter sets which may be used with the sound level meter to determine the frequency characteristics of a sound must meet the requirements of the

Canadian Standards Association (CSA) Standard Z107.5-1975 (ANSI S1.11-1966 (R1976)) "Specification for Octave, Half-Octave, and Third Octave Band Filter Sets."

A magnetic tape recorder which may be used to record a sound for later analysis or to determine the crest factor of a sound signal must meet the requirements of section 5.5 of the Canadian Standard Association (CSA) Standard CSA Z107.2 (ANSI S1.13-1971) "Methods for the Measurement of Sound Pressure Levels". Alternatively, the magnetic tape recorder must have the same performance characteristics specified in clause 3(1) above for the sound level meter. Tape recorders with automatic gain control are not to be used for the above-mentioned purpose.

(3) Noise Dosimeter

A noise dosimeter (also called a personal sound exposure meter) is an instrument that directly integrates a function of sound pressure over a period of time. Dosimeters which are available commercially may provide a measure of either the equivalent sound level Leq for the period of measurement, or the percent daily noise dose expressed as a percentage of the criterion daily sound exposure, or both. A dosimeter is thus useful in the assessment of worker exposure in situations where the sound levels vary either in time or location throughout the work shift.

It should be noted that the measurement provided by the dosimeter of percent daily noise dose is based on the criterion daily duration of 8 hours per day. In order to evaluate the equivalent continuous sound level Leq (40), which is based on a 40 hour work week, as required by the noise regulation, the method described in section 6(2) must be used.

A noise dosimeter used to obtain worker noise exposure measurements required by the noise regulation must meet the requirements of American National Standard ANSI S1.25-1978 "Specification for Personal Noise Dosimeters" (N.B. The Standard ANSI S1.25-1978 is being revised). In accordance with the requirements of the noise regulation, the noise dosimeter must meet the specifications for Class 2A-90/80-3 as defined in section 3.14 of ANSI s1.25-1978. "Class 2" refers to Type 2 tolerances for sound level meters (ANSI S1.4-1971 or CSA Z107.1-1973); "A" refers to the A-weighting network; "90" refers to the criterion sound level of 90 dB at which an 8 hour per day exposure yields 100 percent of the criterion daily sound exposure or allowable daily dose; "80" refers to the lower cutoff or threshold level below which the dosimeter does not respond; and "3" refers to the exchange rate of 3dB between sound level and duration. The dosimeter must have an operating range (as defined in section 3.9 of ANSI S1.25-1978) extending from 80 to at least 120 dB, and preferably 130 dB.

It should be noted that a dosimeter with the stated operating range of 80 to 120 dB which meets the specifications of ANSI S1.25-1978 would probably perform properly for an average sound level of 85 dB with peak values up to 130 dB, thus yielding reliable readings for steady sound levels with high crest factors due to impulsive content. To guarantee such operation, a recent OSHA requirement for dosimeters (Federal Register,Vol. 46, 4078-4179, January 16, 1981) is hereby specified as a preference namely that the dosimeter meet the requirements of section 7.5 of ANSI S1.25-1978 for a test signal at an average A-weighted sound level of 90 dB when the signal has a crest factor (as defined in section 3.4 of ANSI S1.25-1978) of 30 dB.

(4) Integrating-Averaging Sound Level Meter

An integrating-averaging sound level meter is an instrument which provides an integrated or time-averaged measurement of sound levels which vary with time. Since the instrument evaluates an energy average, it thus also provides a determination of the equivalent sound level Leq for the period of measurement. Integrating-averaging sound level meters are available which can average or integrate over times ranging from a few seconds to many hours. They can also detect very short impulses, and some instruments provide a determination of the sound exposure level (SEL) which is a convenient measure of brief, transient, or discontinuous signals. The instruments available commercially can be of Type 1 or Type 2 with various frequency weightings, detector characteristics (fast, slow, peak, impulse), and relatively large dynamic range.

Such an instrument with its wide choice of averaging times may be useful in the assessment of widely fluctuating noise where a time-averaged sound level measurement is desired, particularly if the fluctuations are widely spaced in time by more than one second. However, both IEC and ANSI standards for integrating-averaging sound level meters are in draft stages and are not yet available, so minimum requirements for these instruments necessary to standardize measurements cannot be specified at this time.

4. Types of Noise Measurements

Different types of noise require different measurement techniques and instrumentation, or alternatively stated, specific techniques and instruments should not be used in the assessment of certain noise environments. In addition, different types of noise require different types of data to be obtained and recorded in the overall assessment of the noise environment or worker exposures. A classification of noise by type is given in the CSA standard Z107.2-1973 (ANSI S1.13-

1971) "Methods for the Measurement of Sound Pressure Levels", and although not necessarily rigourous or exhaustive, it is nevertheless useful in indicating the instrumentation which may or may not be used in specific situations. This classification of noise by type is used in the outline below.

Regardless of what type of noise environment is being investigated, it is good practice to carry out a quick preliminary survey before measurements are actually taken in order to assess qualitatively the temporal and spatial character of the noise environment. This preliminary survey provides information on the type of noise present and the appropriate procedures and instrumentation which should be used. Thus observations of the noise field should be made with a Type 1 or Type 2 sound level meter set on the "fast" as well as the "slow" characteristic to identify, for example, the nature of the noise fluctuations or the presence of impulses. The sound level meter set on either the "fast" or "slow" mode should also be moved about in different locations and directions to determine, for example, the areas of highest sound levels, the directionality of the noise field, or the presence of standing waves or interference phenomena.

(1) Steady Noise

Steady noise is characterized by a relatively constant sound level over a long period of time or during the period of measurement. It may or may not contain audible discrete tones. This type of noise can be classified simply by listening since sound level changes of 1 dB or less cannot be detected while changes of 6dB or more are quite apparent. Thus measurements with a sound level meter set on the "slow" mode which vary by less than 6 dB may be considered to be measurements of steady noise. If the average sound level as determined by a sound level meter is relatively constant, but the spectral distribution of the sound changes during the period

of measurement (as determined by listening), the noise should be classified as non-steady and may be required to be frequency-analyzed.

(1) (a) Using a Sound Level Meter

Measurements of the sound level of steady noise should be carried out with a Type 2 or better sound level meter operating on the "slow" meter characteristic and with A-weighting. Any fluctuations of the indicator meter with the instrument operating on the "slow" mode must be less than ±3 dB during the period of measurement. The period of measurement at any one location should typically be 15 seconds or more. The datum to be reported is the average sound level which is approximated by the mean of the maximum and minimum meter indications during the period of measurement. The average sound level corresponds to the root mean square sound pressure during the period of measurement.

Steady noise with audible discrete tones may lead to a situation where there are large spatial variations in sound level caused by standing waves or interference phenomena. To ensure that measurements of sound level are valid and not influenced by local interferences, the microphone position of the sound level meter should be moved about before, and in some cases during, the period of measurement. It may also be desirable to conduct measurements with a narrow band analyzer to determine the frequency and relative strength of the pure tone components, for the purposes of noise control and to evaluate human effects.

The various measures of a worker's exposure, including the equivalent continuous sound level Leq (40) required by the noise regulation, may be evaluated from A-weighted sound level data for steady noise using the methods described in section 6(1). As

discussed in section 6, the total time interval of exposure at each specific sound level must be known either from direct measurement or from other available information. Also information must be available to indicate that the sound levels to which a worker is exposed in an 8 hour day and a 40 hour work week and the durations of exposures are substantially the same as those occurring during the period of measurement.

(1) (b) Using a Noise Dosimeter

Measurements of a worker's exposure to steady noise may be obtained using a noise dosimeter which meets the specifications outlined in section 3(3). The use of a noise dosimieter in the determination of a worker's exposure to noise is to be preferred in situations where the worker moves to several locations with different noise levels during the course of his work day. Dosimeters which are available commercially may provide a measure for the period of measurement of either the equivalent sound level Leq, or the percent daily noise dose expressed as a percentage of the criterion daily sound exposure, or both. However, the measurement of percent daily noise dose is based on the criterion daily duration of 8 hours per day. For the evaluation of the equivalent continuous sound level Leq (40) as required by the noise regulation, see sections 6(2) and 6(3).

If the worker is stationary and the noise is steady throughout the work day, the duration of dosimeter measurement is not critical. If the worker is moving and/or the steady noise attains different sound levels throughout the work day, the duration of dosimeter measurement should be as long as possible. The nature of the noise environment and work pattern should be used to determine the minimum duration of measurement. As discussed in section 6, information must be available (either from direct measurement or from other sources) which will

indicate that the sound levels to which a worker is exposed in an 8 hour day and a 40 hour work week are substantially the same as those occurring during the period of measurement with the dosimeter.

(1) (c) Using an Integrating-Averaging Sound Level Meter

An integrating-averaging sound level meter may be used for steady noise to measure the average A-weighted sound level and/or the equivalent sound level Leq for the period of measurement. Depending on the instrument, integration or averaging times are available which extend from a few seconds to many hours. However, for steady noise at a given location and sound level, the averaging time is not critical; the criterion specified in section 4(1)(a) of 15 seconds or more should be applied. For steady noise, the integrating-averaging sound level meter can be of Type 2 operating with either the "fast" or "slow" characteristic.

The average sound level at a given location for the period of measurement is the datum to be reported. If there is sufficient sound level data for a worker and these data are representative of the noise levels to which he/she is exposed in a 40 hour work week, the various measures of the worker's exposure can be calculated as discussed in sections 4(1)(a) and 6(1).

If the instrument also provides Leq data for the periods of measurement and these data are deemed to be representative of a worker's noise environment for a 40 hour work week, the Leq data may be used to calculate the worker's exposure by the method described in section 6(3). Some instrument manufacturers supply calculation procedures or nomograms for determining the percent daily noise dose for the period of measurement for Leq data. In this mode, the instrument is

being used as a noise dosimeter, and the methods of section 4(1)(b) apply.

(2) Non-steady Fluctuating and Intermittent Noise

In most industrial situations, the sound level is not steady with time. Non-steady noise may be classified as fluctuating, intermittent, or impulsive depending on its temporal characteristics. Fluctuating noise is characterized by a sound level which varies over a range greater than 6 dB (as measured with the "slow" response mode of a sound level meter) either continuously and erratically or between two or more well-defined steady levels. In intermittent noise the sound level deviates momentarily and perhaps repeatedly from the ambient or background level for a time period of one second or more.

(2) (a) Using a Sound Level Meter

As stated earlier, before measurements are actually taken it is good practice to conduct preliminary observations of the noise field with the sound level meter set on the "fast" characteristic, in order to get some idea of the temporal and spatial character of the noise (see above p.5).

A Type 2 or better sound level meter may generally be used in the measurement of fluctuating and intermittent noise. Data are obtained by observing the fluctuations of the indicator meter, generally using the "slow" characteristic unless the purpose of the measurements is to determine the highest sound level in which case the "fast" mode should be used. In the "fast" mode, 0.5 seconds or more should be allowed between measurements. When using the "slow" mode, a longer interval of 2 seconds or more should be allowed between measurements. The period of measurement at any one location

must be 15 seconds or more. The A-weighting is used.

For fluctuating noise which various continuously and erratically over a large range (greater than 6 dB), the datum to be reported is the average sound level during the period of measurement which is the value corresponding to the root mean square sound pressure level. In addition, it is good practice to record the maximum and minimum sound levels during the period of measurement. The maximum and minimum sound levels may be determined using the "slow" meter characteristic if the variation from minimum to maximum occurs in 5 seconds or more; for more rapid variations, the "fast" mode should be used.

The mean indication of the meter may be obtained by averaging a number of readings of the sound level meter operating on the "slow" mode. But it should be noted that this mean meter indication may not correspond to the average sound level (which is the datum to be reported) because of the nature of addition of logarithmic quantities. If the total range of meter fluctuation (measured with the "slow" mode) is less than 6 dB, the mean meter indication is an approximation of the average sound level. If the total range of meter fluctuation is greater than 6 dB, the average sound level may generally be approximated to be 3 DB below the maximum reading or mean of maximum readings. For very large excursions of the meter (greater than approximately 10 dB), a more accurate estimate of the average sound level may be obtained from several readings (10 or more) taken at approximately equal time intervals with the sound level meter operating with the "slow" characteristic, and using the following equation:

$$L = 10 \log \frac{1}{N} \sum_{i=1}^{N} 10^{L_i/10}$$

where L is the average sound level, N is the number of readings, and L_i is the level at each meter reading.

For intermittent or fluctuating noise which varies between two or more well-defined steady values, it is more relevant to determine and report the average sound level at each steady value. The "slow" characteristics of the sound level meter should be used when the sound level is steady at each value for 5 seconds or more. For sound levels that are steady for 1 to 5 seconds, the "fast" mode should be used. For shorter bursts, the noise should be treated as impulsive, and the procedure described in section 4(3)(a) should be used.

The various measures of a worker's exposure, including the equivalent continuous sound level Leq (40) required by the noise regulation, may be evaluated from A-weighted sound level data for flucutating and intermittent noise using the methods described in section #6(1). As discussed in section 6, the total time interval of exposure at each specific sound level must be known either from direct measurement or from other available information. Also information must be available which will indicate that the sound levels to which a worker is exposed in an 8 hour work day and 40hour work week and the durations of exposure are substantially the same as those occuring during the period of measurement.

The use of a Type 2 sound level meter operating on the "slow" characteristic is inadvisable if the fluctuating or intermittent noise has a significant impulsive component. (Impulse noise is discussed in section 4(3) below.) The presence of a signficant impulsive component in the fluctuating or intermittent noise might perhaps be deduced from preliminary observations using the "fast" mode of the sound level meter as discussed earlier. Another test used in practice is to compare the readings

obtained with the A-weighted "fast" mode and A-weighted "slow" mode of a sound level meter. If these readings differ by more than 3 dB, the fluctuating or intermittent noise to be measured might be judged to be largely impulsive. If there is a significant impulsive component, the methods outlined in section 4(3)(a) for the use of a sound level meter for impulse noise should be followed.

(2) (b) Using a Noise Dosimeter

In general a noise dosimeter may be used for both fluctuating and intermittent noise to obtain a measure of a worker's exposure or percent daily noise dose. The use of a dosimeter in the determination of a worker's exposure to noise is to be preferred in situations where sound levels vary throughout the work shift, either in time, as is the case for fluctuating or intermittent noise, or in location if the worker moves about during the course of his work. The crest factor capability of the instrument, which is a measure of its ability to handle rapidly changing sound levels which vary over a large range, should be as high as possible (10 dB or more; OSHA has specified 30 dB as a requirement for dosimeters to meet by 1983). However, it must be kept in mind that the noise dosimeter is basically an integrating sound measuring device operating with a "slow" characteristic. Therefore care must be taken to ensure that the fluctuating or intermittent noise does not contain a significant impulsive component. In order to check whether the noise field is largely impulsive, the tests mentioned in section 4(2)(a) may be used. If there is a significant impulse component, a dosimeter should be used only if it is specified by the manufacturer for the measurement of impulsive noise. Dosimeters operating on a 3 dB exchange rate can be expected to perform better in this regard because of the elimination of the exponent circuit necessary to apply the 5 dB

exchange rate. The recent OSHA requirement for dosimeters mentioned in section 3(3), which is specified in this Code as a preference, is intended to ensure the proper integration of short duration impulses having peak values that are considerably higher than the average sound level.

As discussed in section 4(1)(b), the dosimeter may provide a determination for the period of measurement of either the equivalent sound level Leq or the percent daily noise dose, or both. To evaluate the equivalent continuous sound level Leq (40) as required by the noise regulation, the methods described in sections 6(2) and 6(3) should be used. Since the noise level for fluctuating or intermittent noise may exhibit wide variation with time, the duration of measurement should be as long as possible, and preferably should represent 1/3 or more of the worker's total daily duration of exposure. Alternatively, the nature of the noise environment and work pattern can be used to determine the minimum duration of measurement. For the calculation of the equivalent continuous sound level Leq (40), the dosimeter data for the period or periods of measurement (equivalent should level Leq or percent daily noise dose) must be representative of the worker's exposure for a 40-hour work week.

4 (2) (c) Using an Integrating-Averaging Sound Level Meter

An integrating-averaging sound level meter may generally be used for fluctuating or intermitent noise to measure the average A-weighted sound level and/or the equivalent sound level Leq for the period of measurement. The use of an integrating-averaging sound level meter in determining the average sound level is, in fact, to be preferred to the conventional sound level meter since it takes many more sample measurements of the varying sound at more frequent

intervals and does the averaging automatically, thus yielding a more accurate result. Because fluctuating noise displays widely varying sound levels, an instrument capable of averaging over long periods of time (minutes to several hours), perhaps in a continuous measurement mode, is clearly an advantage and is to be preferred. Where the fluctuating noise does not have a significant impulse component (see section 4(2)(a) for appropriate tests for this), the integrating-averaging sound level meter may be of Type 2 operating on the "slow" characteristic. However, where impulse noise is a significant part of the fluctuating noise environment, the integrating-averaging sound level meter should be used only if it is specified by the manufacturer to be applicable. The characteristics needed are a very large dynamic range (40 dB or greater), a capability to operate with a "fast" response, and a capability to integrate and average over time intervals of several minutes. The instrument should also be of Type 1 tolerance.

The average sound level at a given location for the period of measurement is the datum to be reported. As discussed in section 4(1)(c), if there is sufficient should level data and/or Leq data for a worker, and this data are representative of the workers' noise environment for a 40-hour work week, the various measures of the worker's exposure can be calculated using the method described in section 6(3).

4 (3) Non-Steady Impulse Noise

Impulse noise is characterized by brief excursions of sound pressure which significantly exceed the ambient sound pressure. The duration of a single impulse is in the range of 1 millisecond to 1 second. The sound may consist of isolated single pressure pulses or isolated bursts (multiple pressure

pulses) with a pulse or burst spacing which is typically 1 second or more and which is long compared to their duration. Alternatively, impulse sound may consist of a train or pulses or bursts of equal or unequal amplitudes and/or spacing. As the pulse repetition rate increases, the resolution of individual bursts by a conventional sound level meter becomes difficult, and the sound may then be termed quasi-steady. As a rough guide, if the peaks in noise level corresponding to impulses occur at intervals of 1 second or less, the sound is considered quasi-steady.

4 (3) (a) Using a Sound Level Meter

Quasi-steady impulse noise (at least one peak per second) may be measured with a Type 2 sound level meter. For noise with 5 or more peaks per second, the maximum reading of the sound level meter using the "slow" meter characteristic and A-weighting may be taken as the level of the noise to be reported. For noise with 1 to 5 peaks per second, a similar measurement is less accurate. It is perhaps better to measure this noise with the "slow" meter characteristic of a Type 2 sound level meter, and report the observed average meter indication and the magnitude of the meter fluctuations. The "fast" setting of the sound level meter should also be used to check these measurements.

Isolated pulses or bursts cannot be adequately measured using a conventional sound level meter because the relatively large time constant characteristic of the meter even in the "fast" response mode does not allow the instrument to follow the rapid rise and decay of the impulse. Many Type 1 precision sound level meters include a peak hold detection circuit with a very rapid response time of the order of microseconds and slow decay for easy reading of the peak values. This response time

provides a better indication of the level of the impulse. For isolated impulses, a measurement of the peak sound pressure level should be obtained using the unweighted peak setting on a Type 1 sound level meter. The crest factor capability of the instrument which is a measure of its ability to handle impulse signals must be adequately high for the impulse noise measured.

4 (3) (b) Using a Noise Dosimeter

In general, a noise dosimeter can be used for quasi-steady impulse noise to obtain a measure of a worker's exposure or percent daily noise dose. However, as discussed in section 4(2)(b), the application of a dosimeter to highly impulsive noise may be limited because it is inherently an integrating sound measuring device with a "slow" characteristic. If the dosimeter is not specified by the manufacturer for the measurement of impulsive noise, the measured percent daily noise dose for the quasi-steady noise may be an overestimate of the worker's exposure as the pulse repetition rate decreases to 1 pulse per second or less.

The application of the dosimeter to the measurement of isolated impulses also depends on its capability to handle short duration pulses with high peak values. The manufacturer's specifications should be consulted. The comments made in section 4(2)(b) apply. It is expected that with the recent OSHA requirement for dosimeters (see section 3(3)), the performance capabilities of dosimeters for impulsive-type noise will generally improve.

The determination for the period of measurement of either the equivalent sound level or the percent daily noise dose may be used to evaluate the equivalent continuous sound level Leq (40) or the appropriate contribution to Leq (40) using the methods

described in sections 6(2) and 6(3). As discussed in section 4(2)(b), the duration of measurement should be as long as possible. For the calculation of equivalent continuous should level Leq (40), the dosimeter data for the period of measurement must be representative of the worker's exposure for a 40-hour work week.

4 (3) (c) Using an Integrating-Averaging Sound Level Meter

An integrating-averaging sound level meter may be used for quasi-steady noise to measure the average A-weighted sound level and/or equivalent sound level Leq for the period of measurement. As discussed in section 4(2)(c), the use of an integrating-averaging sound level meter is, in fact, to be preferred to the conventional sound level meter. The instrument may be of Type 2 tolerance operating with the "slow" characteristic, and preferably should be capable of measuring over a duration of at least 1 minute.

The application of an integrating-averaging sound level meter to the measurement of isolated impulses depends on the characteristics of the instrument. Some instruments provide a measurement of the sound exposure level (SEL) which is defined as the sound level which, if maintained constant for 1 second, would contain the same A-weighted energy as the actual impulse event. This parameter, sometimes referred to as the single event noise exposure level (SENEL), represents the sound energy accumulated over the duration of the impulse. It is thus useful for comparing single impulses of different levels and durations. In very specific applications, it may be used in building up a long-term Leq from a knowledge of individual events and their frequency of occurrence. In general terms, an integrating-averaging sound level meter with Type 1 tolerance, a large dynamic range (40 dB or greater), a capability to

operate with a "fast" response, and a capability to integrate and average over time intervals of several minutes may perhaps be used in long-term averaging of isolated impulses to determine a Leq for the period of measurement. The manufacturer's specifications should be consulted.

For quasi-steady noise, the average sound level at a given location for the period of measurement is the datum to be reported. For isolated impulses, the equivalent sound level Leq for the period of measurement is to be reported. As discussed in previous sections 4(1)(c) and 4(2)(c), if the data for a worker is sufficient and representative, they may be used to calculate the equivalent continuous sound level Leq (40) or the appropriate contribution to Leq (40).

4 (4) Combined Steady and Unsteady Noise

The discussion in sections 4(1), 4(2) and 4(3) above treats the different types of commonly encountered noise as isolated cases in order to provide basic guidelines for the selection of appropriate instrumentation and techniques. However, in most situations, steady and unsteady noise or fluctuating and impulsive noise are present simultaneously. Therefore, before noise measurements are taken, the noise environment should be carefully assessed to determine the appropriate techniques and instrumentation which should be used. It is good practice to carry out a quick preliminary survey with a sound level meter set on the "fast" and "slow" characteristic in order to determine qualitatively the temporal character of the noise field. The sound level meter should also be moved about in different locations and directions in order to determine qualitatively the spatial character of the noise environment.

5. PROCEDURE FOR NOISE MONITORING

Noise monitoring for the purpose of the noise regulation falls into the two broad categories of Area Noise Monitoring and Personal Exposure Monitoring. However, noise measurement procedures will vary widely because the noise field and hence the worker's exposure are both influenced by the immediate surroundings. Therefore, it is not possible to specify a standardized monitoring procedure. However, there are certain general considerations which are common to all measurements, and these are outlined below. Guidelines contained in CSA Z-107.53 (draft) "Procedures for Performing a Survey of Sound Due to Industrial, Institutional or Commercial Activities" and ANSI S1.13-1971 "Methods for the Measurement of Sound Pressure Levels" are useful.

In most work places, a combination of both area and personal exposure monitoring provides the most complete information with which to assess a noise problem. For example, area monitoring at a work site may be used to determine if excessive noise exists, to identify the noise sources, and to determine the control measures needed. Personal exposure monitoring will determine more precisely each individual's exposure.

5 (1) Area Noise Monitoring

Area noise monitoring is conducted to determine which areas have excessive noise levels and where noise reduction engineering controls should be implemented. The following are general considerations:

(a) The measuring instrumentation must be appropriate for the type of noise being investigated. The minimum requirements are a sound level meter with a microphone, a calibrator, a watch, and a windscreen.

(b) All noise measuring instruments should be calibrated with an acoustic calibrator in accordance with the manufacturer's instructions before and after each day of use. More frequent calibrations may sometimes be necessary.

(c) SLM readings in a non-reverberant environment should be taken by holding the SLM at arm's length. The microphone placement and orientation relative to the noise source should be in accordance with the manufacturer's instructions. The body of the investigator should be between the noise source and the microphone. Also, the investigator should not be positioned along a straight line passing through the source and microphone, since otherwise the investigator would act as a reflector. The microphone should be in the worker's hearing zone within 0.5 metres of the head position. The worker should not be present when measurements are taken.

(d) Measurements should be taken in all areas where the highest noise levels occur or where workers may be present.

(e) Measurements should be taken at the operator's stations and those sites where workers are most likely to be during their shifts or their rest periods.

(f) Several measurements should be taken throughout a work shift.

(g) Sound level measurements will generally be taken with the A-weighting frequency response. Unweighted or C-weighted readings may be needed for the evaluation of

hearing protectors and the feasibility of implementing engineering controls.

5 (2) Personal Exposure Monitoring

Personal noise exposure monitoring is the most appropriate method of measuring noise in changing work places such as in the construction, mining and lumbering industries where area measurements have limited application. Personal exposure monitoring can be used in such work places to determine which workers are exposed to noise in excess of levels specified by the noise regulation. This helps identify the areas where engineering controls are needed or where personal hearing protection is to be used. This type of noise monitoring is also practical for work areas in which workers are exposed to time-varying noise levels and in which the workers are mobile during the workshift. All data produced from personal exposure monitoring should be recorded and permanently filed in the manner prescribed by the noise regulation.

Personal exposure monitoring should be carried out for workers in high noise areas. Where possible, workers with the highest expected exposure in each job classification should be selected for monitoring. The following is a generalized procedure:

(a) Inform the workers that the dosimeter and microphone should not interfere with normal work, emphasizing that the worker is to continue to work in a routine manner.

(b) Explain the purpose of the dosimeter to each worker.

(c) Instruct the worker not to remove the dosimeter unless absolutely necessary and not to cover the microphone or otherwise influence the recorded noise levels.

(d) Inform the worker when and where the dosimeter will be removed.

(e) Position the dosimeter in the shirt pocket or at the waist. Clip the microphone to the worker's shirt collar at the top of the shoulder. Care should be taken to ensure that the microphone is in a vertical direction, pointing upward towards the ear, and is as close to the ear as possible. Other microphone positions may be selected only if warranted by the noise source.

(f) Position and secure any excess microphone cable to avoid snagging or inconvenience to the employee.

(g) Check the dosimeter periodically to ensure that the microphone is oriented properly.

(h) Take and record independent sound-level meter readings during the different phases of work performed by the worker equipped with a dosimeter during the shift.

(i) Before using dosimeter and sound-level meters in areas where strong electromagnetic or electrostatic fields are present, the manufacturers' instruction manuals should be consulted and potential interference effects should be investigated.

5 (3) Effects of the Environment on Instrument Readings

A number of measurement and environmental factors should be considered before and during noise measurement:

(a) Temperature: Sound measurement equipment is designed to perform at normal ambient temperatures found at the

work place. Special microphones capable of operation at temperature extremes between -29^0C and $+60^0$C are also available if needed. The manufacturer's specifications should be consulted when measurements are to be made under extreme conditions.

(b) Humidity: Condensation on the microphone diaphragm must be avoided.

(c) Corrosive atmosphere: If prolonged sampling is required in corrosive mist atmospheres, the microphone should be protected by a windscreen of closed cell foam construction.

(d) Wind: Air flow across a microphone can produce an error in measurement due to turbulence. A microphone windscreen should be used for all outdoor measurements and where there is significant air movement indoors (e.g., cooling by ventilation fans, gusting wind through open windows). Measurements should not be made when the wind speed at the microphone exceeds the value specified by the manufacturer, or otherwise, 20 km/h. In non-corrosive situations, an open cell windscreen is preferred.

(e) Vibration: Mechanical vibrations of the sound level meter may affect its operation. If possible, the microphone should be decoupled from the SLM. Otherwise, the manufacturer's instructions should be followed.

(f) Magnetic Fields: Certain equipment such as heat sealers, induction furnaces, generators, transformers, electromagnets, arc welders and radio transmitting devices generate electromagnetic fields which, by

inducing current in the electronic circuitry of the instruments, may cause error readings. Whether this condition is significant may be determined by referring to the manufacturer's instructions. If available, a dummy microphone may be used for verification.

6. CALCULATION OF EQUIVALENT CONTINUOUS SOUND LEVEL LEQ (40) AS A MEASURE OF WORKER EXPOSURE.

The equivalent continuous sound level Leq(40) is defined as the constant A-weighted sound level that, over a period of 40 hours, transmits to a worker the same amount of acoustic energy as the actual time varying sound that he is exposed to in a work week. Thus, Leq(40) is a measure of a worker's exposure, and the noise regulation specifies that the exposure of a worker to noise must not exceed a Leq(40) value of 90 dB(A). The purpose of this section is to present the various methods of computing Leq(40) from any of the following data:

- sound level data as obtained with a sound level meter or integrating-averaging sound level meter;

- percent daily noise dose data as obtained with a noise dosimeter;

- equivalent sound level data Leq as obtained with an integrating-averaging sound level meter or noise dosimeter.

In practice, noise measurements are carried out over a time period (or periods) which is a fraction of a worker's total duration of exposure in a work day or work week. However, it is the total exposure of a worker that is of interest, and in order to compute this from measured data, it must be known or ascertained that the

measured noise environment is representative of that in other time periods of exposure. Thus, it is necessary to divide the work day and the work week into a number of time segments of exposure, each having a noise environment of a specific nature. For each time segment where the noise environment is different, noise data which characterize the time segment must be obtained. This is accomplished by carrying out noise measurements as described in sections 4(1) to 4(4), over the entire time segment or a fraction of it. The duration of each time segment of exposure must also be known either from direct measurement or from other available information.

For the purposes of this section, it is assumed that regardless of the type of noise encountered in a work day and work week, the necessary data of sound levels, equivalent sound levels Leq, or percent daily noise dose have been obtained and are available.

6 (1) Calculation of Leq (40) from Sound Level Data

Needed Data:

- All sound levels in dB(A) to which the worker is exposed in a work week.

- Time segments of exposure for each sound level in hours per week.

The general equation for equivalent sound level Leq(T) relative to a time interval T is:

$$Leq\ (T) = 10\ \log_{10} \sum \frac{T_i}{T}\ 10^{L_i/10} \qquad (6.1)$$

where the time segment T_i is the total duration in hours that the sound level is L_i, and the sum is over all time segments relative to the interval T. The equation for the equivalent continuous sound level Leq(40), defined relative to T = 40 hours, is therefore:

$$Leq\ (40) = 10\ \log_{10} \sum \frac{\Delta\ t_i}{40}\ \ 10^{\ L_i/10} \qquad (6.2)$$

where the time segment t_i is the total duration in hours per week that the sound level is L_i. It should be noted that it is not necessary for the sum of the time segments ($\sum \Delta t_i$) to be equal to the criterion duration of 40 hours. For example, there may be time segments in which the worker is not exposed to noise, as illustrated in Example 1 below, and the contribution of these time segments to Leq(40) is negligible. Alternatively, the worker could work overtime and be exposed to significant noise for more than 40 hours, as illustrated in Example 2 below:

Method 1 The value of Leq(40) for a worker can be calculated using equation (6.2) if the needed data specified above are available.

* *

The ISO standard 1999-1975(E) presents the calculation of Leq(40), represented by equation (6.2), by means of tables. Two tables are required in order to make the numbers in the tables reasonable in size. From equation (6.2):

$$Leq(40) = 10\ \log_{10} \sum \frac{\Delta t_i}{40}\ \ 10^{\ 0.1(L_i\ -\ 70)}\ 10^7$$

$$= 70 + 10\ \log_{10} \sum\ E_i \qquad (6.3)$$

where E_i = partial noise exposure index for sound level L_i and duration Δt_i

$$= \frac{\Delta t_i}{40} \; 10^{0.1(L_i - 70)} \qquad (6.4)$$

and $\sum E_i$ = composite noise exposure index

Table 6.1 gives the values of the partial noise exposure index E_i for different sound levels and durations, as calculated from equation (6.4). Table 6.2 gives the relation between the composite noise exposure index and Leq(40), as calculated from equation (6.3).

Method 2 The value of Leq(40) for a worker can be calculated using Tables 6.1 and 6.2 if the needed data specified above are available.

Step 1 - For each sound level and duration of exposure per week, determine the partial noise exposure index E_i from Table 6.1. If the total weekly duration for a specific sound level is less than 10 minutes, the minimum value of 10 minutes should be used.

Step 2 - Compute the arithmetic sum of the E_i values to determine the composite noise exposure index $\sum E_i$.

Step 3 - Using the value of the composite noise exposure index in Table 6.2, determine Leq(40).

Example 1: In 1 week, a worker's exposure to noise is as follows:

t_i :-	hrs	min	L_i dB(A)
#1	4		85
#2	20		90
#3	10	30	105
#4	5	30	less than 80
Total	40 hours		

Method 1: Using equation (6.2)

$$Leq(40) = 10 \log_{10} \left[\frac{1}{40} \left(4\times10^{8.5} + 20\times10^{9} + 10.5\times10^{10.5} + 5.5\times10^{8}\right)\right]$$
$$= 99.5 \text{ dB(A)}$$

Method 2: Using Tables 6.1 and 6.2

E_i values:	#1	#2	#3	#4
	5	50	790+40	0

$\sum E_i$: 885

$Leq(40)$ = 99 - 100 dB(A) (from Table 6.2)

= 99.4 dB(A) (by interpolation)

Example 2: The worker in example 1 works overtime and is exposed to 100 dB(A) for an additional 5 hours:

Method 2 Additional E_i = 125

$\sum E_i$ = 1010

$Leq(40)$ = 100 dB(A) (from Table 6.2)

6 (2) Calculation of Leq(40) from Dosimeter Data of Percent Daily Noise Dose

Needed Data:

- Percent daily noise dose data for each characteristic time segment in a work week in which the noise environment is of a specific nature.

In using a noise dosimeter, it is important to keep the following points in mind:

1. A noise dosimeter is operated on a day-to-day basis. It is either unusual or impossible to use a dosimeter to monitor the cumulative exposure of a worker for several successive days.

2. Commercially-available dosimeters operate on a time basis of 8 hours (criterion daily duration), and the percent daily noise dose is measured by the dosimeter using this time basis.

3. Commercially-available dosimeters operate on a sound level basis of 90 dB (criterion sound level). This is the steady sound level at which an 8 hour exposure per day produces a percent daily noise dose of 100%.

Notwithstanding the above-mentioned points, the noise regulation requires that the equivalent continuous sound level Leq(40) be determined on the basis of a 40 hour week. Therefore, the calculation of Leq(40) from the percent daily noise dose measurements determined by a dosimeter must take these factors into account.

The calculation method is summarized as follows:

1. Because the dosimeter operates one day at a time with a

time basis of 8 hours and a sound level basis of 90 dB, it is valid to convert the percent daily noise dose measurement for a given day into a equivalent 8 hour time-weighted average sound level (TWA). The TWA value is the A-weighted sound level which, if constant over an 8 hour duration, would result in the same percent daily noise dose that the dosimeter would measure for the time varying sound that a worker is exposed to in 1 work day. The relationship between TWA and the percent daily noise dose D is

$$TWA = 10 \log_{10} \left[\frac{D}{100} \right] + 90 \qquad (6.5)$$

where D is in %. The relationship between D and TWA as calculated from equation 6.5 is given in Table 6.3.

2. The value of TWA for a given work day, as converted from the D measurement for the same work day, represents a sound level to which a worker is exposed for 8 hours. Thus, the TWA values for all the work days in a week can be used to calculate Leq(40) using the method described in section (6.1).

The procedure for the calculation of Leq(40) thus consists of the following 3 steps:

Step 1: Determine the percent daily noise dose for each work day in a week that the sound environment is different. Only one day needs to be investigated if the noise environment is the same from day to day. In a given day, dosimeter measurements must be carried out

for each time segment in which the noise levels are different. Because dose values are based on energy and energy is an additive quantity, the percent daily noise dose for each work day is a sum of the individual dosimeter measurements for each time segment of that day.

Step 2: Convert the percent daily noise dose values to TWA values for each work day of 1 week.

Step 3: Using each TWA value as a sound level value with a duration of 8 hours, compute Leq(40) by the method described in section 6(1).

Example 3: Dosimeter measurements taken in 1 work day which is typical of every day in a week are as follows:

Time segment #1: Noise environment is of a specific nature:
Exposure time = 3 hours
Sampling time = 2 hours
Dosimeter reading (2 hrs.) = 80%

Extrapolated dosimeter reading (3 hrs) = $\frac{3}{2}$ x 80% = 120%

Time segment #2: Noise environment is of a specific nature:
Exposure time = 4 hours
Sampling time = 2 hours
Dosimeter reading (2 hrs.) = 98%

Extrapolated dosimeter reading (4 hrs.) = $\frac{4}{2}$ x 98% = 196%

Percent daily noise dose = 120 + 196 = 316%

From Table 6.3, TWA for 1 work day = 95 dB(A)
From Table 6.1, E_i value for 95 dB(A) at 8 hrs. = 65

For 5 days/week $\sum E_i = 5 \times 65 = 325$
From Table 6.2, Leq(40) = 95 dB(A)

N.B. The values of Leq(40) and TWA are the same only if there are 5 work days per week and the noise environment in each day is the same. (See example 4 for case of 4 days/week).

6. (3) Calculation of Leq(40) from Leq Data as Obtained with a Dosimeter or Integrating-Averaging Sound Level Meter

Needed Data

- Leq data for each characteristic time segment in a work week in which the noise environment is of a specific nature.

Since the Leq measurement is, in essence, a sound level of an equivalent steady noise for the period of measurement, one needs only to identify the time segment in which the noise environment is the same as that measured. The value of Leq(40) can then be calculated using the method outlined in section 6(1).

A useful relationship for the calculation of an overall Leq value for one work day is:

$$\text{Leq (1 day)} = 10 \log_{10} \frac{\sum \Delta t_i}{T} \; 10^{0.1(\text{Leq}_i)} \qquad (6.6)$$

where Leq_i and Δt_i are respectively the Leq values and durations of the separate time segments in the work day in which the noise environment is different.

Example 4: Worker works for 4 days. The Leq measurements taken in 1 work day which is typical of every day in the week are as follows:

Time Segment #1: Noise environment is of a specific nature:
Exposure time = 3 hours
Sampling time = 1 minute
Leq (1 min) = 93 dB(A)

Time Segment #2: Noise environment is of a specific nature:
Exposure time = 4 hours
Sampling time = 1 minute
Leq (1 min) = 96 dB(A)

Method: If 1 minute sampling in each time segment is adequate to define the noise environment in that time segment:

For time segment #1: Leq (3 hrs) = 93 dB(A)
time segment #2: Leq (4 hrs) = 96 dB(A)

From equation 6.6:

$$\text{Leq (7 hours)} = 10 \log_{10} \left[\frac{1}{7} \left(3 \times 10^{9.3} + 4 \times 10^{9.6} \right) \right]$$
$$= 95 \text{ dB(A)}$$

From Table 6.1, E_i value for 95 dB(A) at 7 hours = 55
For 4 days $\Sigma E_i = 4 \times 55 = 220$
From Table 6.2, Leq(40) = 93.4 dB(A)

7. CALCULATION OF PERCENT DAILY NOISE DOSE FROM SOUND LEVEL AND LEQ MEASUREMENT.

The noise regulation specifies that a worker's exposure to noise is to be measured in terms of the equivalent continuous sound level, Leq(40), which is based on a 40 hour work-week. All the necessary calculations for calculating Leq(40) from the various types of noise measurements (sound level, percent daily noise dose, and Leq measurements) are outlined in Section 6. There is no requirement in the noise regulation for the calculation of percent daily noise dose. However, a knowledge of the percent daily noise dose for a worker is desirable for the following reasons:

(a) To determine if a worker's exposure to noise in 1 work day is unusually high, and consequently, to alert the employer and worker that a similar exposure in subsequent days of a work week will result in an Leq(40) value greater than 90 dB(A), in violation of the noise regulation.

(b) To compare the percent daily noise dose value calculated form sound level measurements with the value measured directly with a dosimeter.

7(1) Calculations of Percent Daily Noise Dose from Sound Level Measurements

the percent daily noise dose D (in percent) is calculated from sound level data by means of the following equation:

$$D = 100 \left[\frac{C_1}{T_1} + \frac{C_2}{T_2} + \ldots \frac{C_n}{T_n} \right] \qquad (7.1)$$

In equation 7.1, C_n indicates the total time of exposure at a specific sound level, L_n and T_n indicates the reference duration for that level which is defined as,

$$T_n = \frac{8}{2^{(L_n - 90) / 3}} \qquad (7.2)$$

Reference durations for the various sound levels, calculated in accordance with equation (7.2) are given in Table 7.1. The reference duration at a given sound level is defined as the time period over which an exposure to that sound level would equal the criterion daily sound exposure. It can be seen from equation (7.2) that an exchange rate of 3 dB is inherent in the reference duration as defined.

Example 5: In 1 work day, a worker's exposure is as follows:

	C_i			Reference Duration
	hrs.	mins.	L_idB(A)	T_i (hrs.; from Table 7.1)
#1	5		85	25.4
#2	2		93	4.0
#3	0	30	97	1.6
#4	0	30	103	0.40
#5	1		less than 80	81
Total	9 hours			

Using equation (7.1):

$$D = 100 \left[\frac{5}{25.4} + \frac{2}{4} + \frac{0.5}{1.6} + \frac{0.5}{0.4} + \frac{1}{81} \right]$$
$$= 227\%$$

N.B. It should be noted from this example that the duration of a work shift does not have to equal the criterion daily duration of 8 hours.

* * * * * * * * *

7.(2) Calculation of Percent Daily Noise Dose from Leq Measurements

Since the Leq measurement is, in essence, a sound level of an equivalent steady noise for the period of measurement, one needs only to identify the time segment in which the noise environment is the same as that measured. The percent daily noise dose can then be calculated using equation (7.1):

Example 6: (Same as example 4)
The Leq measurements taken in 1 work day are as follows:

Time Segment #1: Noise environment is of a specific nature:
Exposure time = 3 hours
Sampling time = 1 minute
Leq (1 min) = 93 dB(A)

Time Segment #2: Noise environment is of a specific nature:
Exposure time = 4 hours
Sampling time = 1 minute
Leq (1 min) = 96 dB(A)

Method: If 1 minute sampling in each time segment is adequate to define the noise environment in that time segment:

For time segment #1: From Table (7.1)

Leq (3 hrs) = 93 dB(A) Reference Duration = 4.0

For time segment #2:

Leq (4 hrs) = 96 dB(A) Reference Duration = 2.0

Using equation (7.1):

$$D = 100 \left[\frac{3}{4} + \frac{4}{2} \right] = 275\%$$

8. WORK PLACE RECORDS

Maintenance of proper operational and data records is a very important aspect of the measurement component of the hearing conservation program. The following is a list of information items to be recorded, if possible:

(a) Types, models, and serial number (or other identification) of the measurement instrumentation used.

(b) A description or sketch of the measurement location and its relation to the sources of interest (distance, direction) including the orientation of the microphone.

(c) Noise characteristics (fluctuating level, impulsive, etc).

(d) Description of the noise sources and/or processes (type, speed, power, model, condition, operating mode, existing noise controls, etc).

(e) Description and location of extraneous noise sources.

(f) General information

- data and time of measurements

- meteorologic conditions
- results of calibration and operational tests
- person conducting measurements.

(g) Worker data:

- distance of worker from primary noise source;
- work pattern (stationary-mobile);
- time pattern of exposure;
- noise level data and/or exposure data with appropriate detail on sampling times, methods of computation, etc;
- whether hearing protection is provided and/or used;
- existence of auditory problems. Time since the last audiometric examination and frequency of examinations.

(h) Area Noise data:

- building data (size and shape of room; layout of equipment, work stations, and break areas; type of surface materials; existing acoustical treatment; presence of barriers and enclosures);

- noise level data with appropriate detail on sampling times, methods of computation, etc.

(i) Other relevant information (noise control measures, administrative controls, etc).

APPENDIX

DEFINITIONS

NOTE:

1. These definitions apply only for the purposes of this Code.

2. In this Code, noise and sound are considered to be equivalent terms.

Composite noise exposure index - The sum of partial noise exposure indices for all relevant sound levels over a working week of 40 hours (as defined in ISO standard 1999-1975 (E)).

Crest factor - absolute value of the ratio of the peak value and the root-mean-square value measured over a specified time interval where both values are measured in reference to the arithmetic mean value of the wave.

Criterion daily duration - A duration of 8 hours which is used as the time basis for measurment by a dosimeter.

Criterion daily sound exposure - The product of the criterion daily duration (8 hours), and the mean-square sound pressure corresponding to the criterion sound level (90 dB).

Criterion duration - 40 hours in one work week.

Criterion sound exposure - The product of the criterion duration (40 hours) and the mean-square sound pressure corresponding to the criterion sound level (90 dB).

Criterion sound level - A sound level of 90 dB, which is the

basis for measurement by a noise dosimeter to meet the requirements of the noise regulation. It is the steady level in dB at which 8 hour exposure produces a percent daily noise dose of 100%.

Decibel (dB) - Unit of measurement of sound level and sound pressure level.

Decibel A-weighed, dB(A) - Unit of measurement of sound pressure level corrected to the A-weighted scale.

Equivalent continuous sound level, Leq (40) - That sound level in dB(A) which, if present for 40 hours in one week, produces the same composite noise exposure index as the various measured sound levels over one week (as defined in ISO standard 1999-1975(E)). Unit dB(A).

Equivalent sound level Leq - The A-weighted sound level in dB(A) of a steady sound which contains the same total accoustic energy integrated over a specified time period as the actual time varying sound of interest. The time interval in hours is specified in brackets. Examples Leq(8), Leq(4)).

NB: Leq(8) is synonymous with the TWA sound level.

Exchange rate - The number of dB increases or decreases which causes the exposure time to be respectively halved or doubled, if the sound exposure is to remain unchanged. For the noise regulation, the exchange rate is 3 dB.

Operating range or dynamic range of a dosimeter - The range between the threshold level and an upper sound level within which the dosimeter operates within stated tolerances.

Partial noise exposure index - An index determined by a sound

level and its duration within a work week (as defined in ISO standard 1999-1975(E)).

Peak sound pressure level - The peak instantaneous sound pressure level. Unit: dB.

Percent daily noise dose - The ratio of the sound exposure and the criterion daily sound exposure, expressed as a percentage.

Percent noise dose - The ratio of the sound exposure and the criterion sound exposure, expressed as a percentage.

Sound exposure or noise exposure - The time integral, over a stated time or event, of the SLOW or FAST (as appropriate for the measurement) exponential time-averaged, squared, A-weighted, sound pressure signal.

Sound exposure level - The sound level which, if maintained constant for 1 second, would contain the same A-weighted acoustic energy as the actual acoustic event. Unit dB(A).

Sound level or noise level - Sound pressure level measured by use of a metering device and weighting A, B or C. The weighting employed is specified in brackets. Unit: dB.

Sound pressure level - 20 times the logarithm to the base 10 of the ratio of the pressure of a sound to the reference pressure of 20 micropascals. Unit: dB.

Threshold level of a dosimeter - The sound level in dB below which the dosimeter produces little or no indication. It is the sound level at which integration begins.

Time-weighted average (TWA) sound level. The A-weighted sound

level which if constant over an 8 hour duration, would result in the same percent daily noise dose as is measured with a dosimeter or calculated from sound level measurements. Units dB(A).

N.B. TWA is synonymous with equivalent sound level for 8 hours, Leq(8).

Table 6.1 - Partial noise exposure indices for sound levels 80 to 120 dB(A) and duration 10 min. to 40 hr. per week.

Duration per week		Partial noise exposure indices, E_i								
		Sound level in dB(A)								
hr	min	80	85	90	95	100	105	110	115	120
	10					5	15	40	130	415
	12					5	15	50	160	500
	14					5	20	60	185	585
	16					5	20	65	210	665
	18					10	25	75	235	750
	20					10	25	85	265	835
	25				5	10	35	105	330	1040
	30				5	15	40	125	395	1250
	40				5	15	55	165	525	1670
	50				5	20	70	210	660	2080
	60			5	10	25	80	250	790	2500
	70			5	10	30	90	290	920	2920
	80			5	10	35	105	330	1050	3330
	90			5	10	40	120	375	1190	3750
	100			5	15	40	130	415	1320	4170
2				5	15	50	160	500	1580	5000
2.5				5	20	65	200	625	1980	6250
3				10	25	75	235	750	2370	7500
3.5		5		10	30	90	275	875	2770	8750
4		5		10	30	100	315	1000	3160	10000
5		5		15	40	125	395	1250	3950	12500
6		5		15	45	150	475	1500	4740	15000
7		5		20	55	175	555	1750	5530	17500
8		5		20	65	200	630	2000	6320	20000
9		5		25	70	225	710	2250	7110	22500
10		10		25	80	250	790	2500	7910	25000
12		10		30	95	300	950	3000	9490	30000
14		10		35	110	350	1110	3500	11100	
16		5	15	40	125	400	1260	4000	12600	
18		5	15	45	140	450	1420	4500	14200	
20		5	15	50	160	500	1580	5000	15800	
25		5	20	65	200	625	1980	6250	19800	
30		10	25	75	235	750	2370	7500	23700	
35		10	30	90	275	875	2770	8750	27700	
40		10	30	100	315	1000	3160	10000	31600	

The values are calculated from the formula

$$E_i = \Delta \frac{t_i}{40} \; 10^{0.1\,(L_i - 70)}$$

Table 6.2 - Relation between composite noise exposure index and equivalent continuous sound level Leq(40)

Composite Noise Exposure Index	Equivalent Continuous Sound Level Leq(40) dB(A)
10	80
15	82
20	83
25	84
30	85
40	86
50	87
60	88
80	89
100	90
125	91
160	92
200	93
250	94
315	95
400	96
500	97
630	98
800	99
1,000	100
1,250	101
1,600	102
2,000	103
2,500	104
3,150	105
4,000	106
5,000	107
6,300	108
8,000	109
10,000	110
12,500	111
16,000	112
20,000	113
25,000	114
31,500	115

The values are calculated from the formula:

$$Leq = 70 + 10 \log_{10} \sum E_i$$

Table 6.3 — Conversion From Percent Daily Noise Dose (D) to 8 hour Time-Weighted-Average Sound Level (TWA)

D (%)	TWA dB(A)	D (%)	TWA dB(A)	D (%)	TWA dB(A)	D (%)	TWA dB(A)	D (%)	TWA dB(A)
10	80.0	110	90.4	220	93.4	450	96.5	950	99.8
20	93.0	120	90-8	240	92.8	500	97.0	1000	100.0
30	84.8	130	91.1	260	94.1	550	97.4	1200	100.8
40	86.0	140	91.5	280	94.5	600	97.8	1400	101.5
50	87.0	150	91.8	300	94.8	650	98.1	1600	102.0
60	87.8	160	92.0	320	95.1	700	98.5	1800	102.6
70	88.5	170	92.3	340	95.3	750	98.8	2000	103.0
80	89.0	180	92.6	360	95.6	800	99.0	2200	103.4
90	89.5	190	92.8	380	95.8	850	99.3	2400	103.8
100	90.0	200	93.0	400	96.0	900	99.5	2600	104.1

Table 7.1 - Reference Duration for Different A-weighted Sound Levels

Sound Level dB(A)	Reference Duration (hrs)	Sound Level dB(A)	Reference Duration (hrs)	Sound Level dB(A)	Reference Duration (hrs)	Sound Level dB(A)	Reference Duration (hrs)
80	81.0	90	8.0	100	0.79	110	0.080
81	64.0	91	6.3	101	0.63	111	0.063
82	50.8	92	5.1	102	0.50	112	0.050
83	40.5	93	4.0	103	0.40	113	0.040
84	32.0	94	3.2	104	0.32	114	0.031
85	25.4	95	2.5	105	0.25	115	0.025
86	20.3	96	2.0	106	0.20	116	0.020
87	16.0	97	1.6	107	0.16	117	0.016
88	12.7	98	1.3	108	0.13	118	0.012
89	10.1	99	1.0	109	0.10	119	0.010
						120	0.008

The values are calculated from the formula

$$T = \frac{8}{2^{(L - 90)/3}}$$

APPENDIX Mb

CODE FOR NOISE MEASUREMENT

MINISTRY OF LABOUR
OCCUPATIONAL HEALTH AND SAFETY DIVISION
November 23, 1981

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NOISE MEASUREMENT

1. Purpose

(1) To establish uniform procedures for conducting noise measurements.

(2) To assist in the determination as to whether a hearing conservation program is required.

(3) To satisfy the provisions of a hearing conservation program and identify the areas where engineering controls and hearing protectors are needed.

2. Instrumentation

(1) Sound Level Meter - A sound level meter is an instrument which measures sound pressure levels with a frequency weighting and a time characteristic. The sound level meter, including the microphone, must meet the performance requirements of the International Electrotechnical Commission (IEC) Standard IEC 651-1979 "Sound Level Meters".

For the purposes of this code, a sound level meter must have the following characteristics defined in the standard:

(a) Type 1 or Type 2 tolerances.

(b) A minimum operating range extending from 80 to 130 dBA (or dBC). The operating range of a sound level meter is defined as the range between the lower and upper noise levels within which the instrument operates linearly within tolerances specified in the standard. For measurements of background sound levels in audiometric

sound-proof booths, the operating range must extend to 30 dBA. For measurements of peak sound pressures of isolated impulses, the operating range must extend to 140 dB.

(c) An A - and/or C - weighting frequency characteristic, as appropriate (see section 3(4)(d)). An optional frequency weighting characteristic designated as "Lin", "Linear" or "Flat", when provided, can be a substitute for the C-weighting.

(d) Time weighting characteristics designated as "slow" and "fast". A "peak" characteristic is required for the measurement of isolated impulses.

(e) For the measurement of impulse noise, an adequately high crest factor capability of at least 10 dB or otherwise sufficient to meet the requirements of the measurement.

(2) Octave and Third - Octave Band Filter Sets - Octave and third - octave band filter sets are used with a sound level meter or an integrating-averaging sound level meter to measure noise levels in specific frequency bands. These instruments must meet the performance requirements of the Canadian Standards Association (CSA) Standard Z107.5-1975 "Octave, Half-Octave, and Third-Octave Band Filter Sets."

For the purposes of this code, an octave band filter set must have a range of filter bands designated as Type E (extended range), and minimum performance specifications designated as Class I or II. A third-octave band filter set must have Type E (extended range) and Class II or III designations.

(3) Noise Dosimeter - A noise dosimeter is an instrument which directly integrates a function of the sound pressure over a period of time to provide a measure of the percent daily noise dose. A dosimeter is thus useful in the assessment of worker exposure in situations where the noise levels vary either in time or location throughout the work shift. The noise dosimeter including the microphone, must meet the performance requirements of the American National Standards Institute (ANSI) standard ANSI S1.25-1978 "Specification for Personal Noise Dosimeters", pending the publication of an IEC standard for personal sound exposure meters (dosimeters).

For the purposes of this code, a noise dosimeter must have the following characteristics defined in the standard:

(a) A type 2 tolerance as specified in IEC 651-1979 for sound level meters;

(b) An A - weighting frequency characteristic;

(c) A time weighting characteristic designated as "slow";

(d) A criterion noise level of 90 dB at which an 8 hour per day exposure yields 100% of the criterion daily noise exposure;

(e) A threshold level of 80 dB;

(f) An exchange rate of 3 dB between noise level and exposure duration;

(g) A minimum operating range extending from 80 to at least 120 dB, or otherwise sufficient to meet the requirements of the measurement; and

(h) For the measurement of impulse noise, an adequately high crest factor capability of at least 10 dB, or otherwise sufficient to meet the requirements of the measurement.

(4) Integrating-Averaging Sound Level Meter - An integrating-averaging sound level meter is an instrument which is capable of operating as a conventional sound level meter with a time-averaging capability such as "slow" and "fast", and which is also capable of integrating a function of the sound pressure over a period of time. The instrument can provide several types of measurements including the equivalent sound level (L_{eq}) for the period of measurement.

Pending the publication of an IEC standard for integrating-averaging sound level meters, the instrument including the microphone must meet the performance requirements of the IEC standard, IEC 651-1979 for the conventional sound level meter. The instrument must also possess a computation circuit which integrates the mean square function of the frequency-weighted sound pressure with respect to time, and provides a value of the equivalent sound level.

For the purposes of this code, the integrating-averaging sound level meter must have the following characteristics:

(a) Type 1 or Type 2 tolerances as specified in IEC 651-1979.

(b) A minimum operating range extending from 80 to 130 dBA (or dBC). For measurements of background sound levels in audiometric sound-proof booths, the operating range must extend to 30 dBA. The operating range is defined as the range between the lower and upper noise levels within which the instrument operates with a linearity of $\pm$ 1 dB.

(c) As appropriate (see section 3(4)(d)), an A- and/or C-weighting frequency characteristic as specified in IEC 651-1979. An optional frequency weighting characteristic designated as "Lin", "Linear" or "Flat", when provided, can be a substitute for the C-weighting.

(d) A computation circuit capable of integrating the mean square function of the A- or C-weighted sound pressure for a time period of one minute or more at the maximum noise level for a selected level range.

(e) One or more level range settings where any one level range must be at least 30 dB and have an overlap of at least 10 dB between adjacent levels. For any level range setting, the instrument must provide for a suitable overload indication if the measured noise level is outside the range.

(f) For the measurement of impulse noise, an adequately high crest factor capability of at least 10 dB, or otherwise sufficient to meet the requirements of the measurement.

3. Noise Measurement

Noise measurements for the purposes of the noise regulation and associated codes (Hearing Protection; Audiometry) fall into two broad categories-Area Noise Measurement and Personal Exposure Measurement. Since noise environments are highly variable and noise measurement not readily standardized, the general measurement procedures for these categories, described in section 3(3), must be used in conjunction with the specific procedures, described in section 3(4), for different types of noise, A- and C-weighted noise level measurements, and spectral analysis.

(1) Area Noise Measurement - Noise level measurements can be used to determine:

- the presence of a noise hazard,
- the need for a hearing conservation program,
- the background sound levels in audiometric sound-proof booths, and
- the selection of appropriate hearing protectors.

Sound level meters, may be used in area noise measurement. For the purposes of this code, noise dosimeters and integrating-averaging sound level meters may also be used in area noise measurement provided they are set to integrate noise levels for time periods not greater than one minute in duration. The measurements consist of noise level data and/or 1 minute L_{eq} data.

(2) Personal Exposure Measurement - The worker's personal noise exposure level can be used to determine:

- the need for engineering controls,
- the need for hearing protection.

Sound level meters, noise dosimeters, and integrating-averaging sound level meters may be used in personal exposure measurement to determine noise level data, percent daily noise dose data, and/or equivalent sound level data. The use of dosimeters is very effective in work places where workers are exposed to time-varying noise levels and where workers are mobile during the work shift.

(3) General Procedures

(a) Calibration

The instruments must be calibrated with an acoustic

calibrator of known frequency and sound pressure level in accordance with the manufacturer's instructions before and after each day of use. More frequent calibrations may sometimes be necessary. If the instrument calibration changes by more than ± 1 dB from the previous calibration, the measurements must be rejected.

(b) Battery Check

If the instrument is battery-powered, the condition of the battery must be checked in accordance with the manufacturer's instructions before and after each day of use.

(c) Environmental Conditions

A number of environmental factors must be considered before and during noise measurement. These are temperature, humidity, wind, vibration, corrosive atmospheres, explosive atmospheres, and magnetic fields. The manufacturer's instructions regarding measurement and environmental conditions must be followed.

(d) Time Segments for Representative Sampling

The work day and work week must be divided into a number of time segments. These time segments must reflect the variability of the noise environment, and within each segment the noise must be relatively uniform and of a specific character. A time segment may be a fraction of a work day, a full work day, or a full work week.

(e) Instrument Setting

The instrument must be set (frequency weighting characteristic-A, C, or Linear; time weighting characteristic- "slow", "fast", or "peak") in accordance with the specific procedures described in section 3(4) for different types of noise.

(f) Instrument Configuration in Area Noise Measurement

(i) The microphone must be positioned in the hearing zone of the worker within 0.5 metres of the estimated head position.

(ii) The microphone must be positioned not less than 1 metre above the floor and preferably not less than 1 metre from any sound-reflecting surface.

(iii) The microphone must be held at arm's length from the body of the investigator, and at a right angle to the straight line passing through the source and the investigator. The body of the investigator must not be between the noise source and the microphone.

(iv) The microphone must be oriented relative to the noise source at the angle of incidence recommended by the manufacturer for flattest frequency response in a free field.

(g) Instrument Configuration in Personal Exposure Measurement: Noise Dosimeter

(i) The noise dosimeter must be positioned in the

shirt pocket or at the waist. The microphone must be positioned above the shoulder and be as close to the ear as possible. Generally, the microphone orientation will be vertical, but other orientations may be used if warranted by the noise source.

(ii) Any excess microphone cable must be secured to avoid snagging or inconvenience to the worker.

(iii) The microphone must be checked periodically to ensure that it is oriented properly.

(h) Instrument Configuration in Personal Exposure Measurement: Sound Level Meter and Integrating-Averaging Sound Level Meter

(i) The microphone must be positioned as close to the worker's ear as possible. The worker must be present when personal exposure measurements are taken with a sound level meter or integrating-averaging sound level meter.

(ii) The microphone must be held at arm's length from the body of the investigator and at a right angle to the straight line passing through the source and the investigator. The body of the investigator must not be between the noise source and the microphone.

(iii) The microphone must be oriented relative to the noise source at the angle of incidence recommended by the manufacturer for flattest frequency response in a free field.

(i) Instructions to the Worker: Noise Dosimeter

The purpose of the noise dosimeter must be explained and the worker must be instructed as follows:

(i) To continue to work in a routine manner and not allow the dosimeter and microphone to interfere with normal work.

(ii) Not to remove the noise dosimeter and microphone unless absolutely necessary.

(iii) Not to cover the microphone, or otherwise influence the measurements.

(j) Instructions to the Worker: Sound Level Meter and Integrating-Averaging Sound Level meter

The purpose of the instrument must be explained and the worker must be instructed to continue to work in a routine manner and not allow the instrument or the investigator to interfere with normal work.

(k) Measurement Locations in Area Noise Measurement

Measurements should be taken in the following locations:

(i) Where the noise levels are thought to be high;

(ii) At work stations and work areas, to obtain a representative record of the noise environment;

(iii) In audiometric sound-proof booths.

(l) Workers to be Monitored in Personal Exposure Measurement

Personal exposure measurements must be carried out for workers with the highest noise exposures in each job category. Measurements for one worker may be used to represent similarly exposed workers.

(m) Readings at a Measurement Location and for a Worker

(i) Area noise and personal exposure readings must be taken in accordance with the specific procedures described in section 3(4) for different types of noise.

(ii) If the instrument is not equipped with an internal elapsed-time clock, the investigator must determine the period of measurement at a given location by means of a time-measuring device.

(iii) An area noise level or personal exposure value obtained as described in section 3(4) from a set of readings in a specific period of measurement must be characteristic and representative of an entire time segment of a work day or work week.

(iv) Readings and area noise level or personal exposure values derived from them must be obtained for every time segment of a work week in which the noise environment is significantly different.

(v) When using a sound level meter or integrating-

averaging sound level meter in personal exposure measurement, readings in any time segment should be taken at locations selected to be representative of the noise exposure of the worker in that time segment.

(vi) The acoustic characteristics of the environment must not be modified while measurements are being taken.

(vii) In personal exposure measurement, the equivalent sound exposure level, L_{ex} for the worker monitored must be calculated in accordance with the methods outlined in section 4.

(4) Specific Procedures

The Canadian Standards Association (CSA) standard Z107.2-1973 "Methods for the Measurement of Sound Pressure Levels" classifies noise as follows:

Steady Noise (with and without audible discrete tones)

Non-Steady Noise (with and without audible discrete tones)

- fluctuating noise,
- intermittent noise,
- impulse noise:
  - isolated impulses,
  - quasi-steady noise.

Although these types of noise are not typically encountered as isolated cases, every noise environment can generally be assessed in terms of them.

Regardless of the type of noise being investigated, it is good practice to carry out a preliminary walk-through survey before measurements are actually taken in order to assess qualitatively the temporal and spatial character of the noise environment. This preliminary survey will provide information on the type of noise present, and hence on the appropriate measurement techniques and instrumentation to be used. Observations of the noise environment should be made with a Type 1 or Type 2 sound level meter set on the "fast" as well as the "slow" response to identify, for example, the nature of the noise fluctuations or the presence of impulses. The sound level meter, set on either the "fast" or "slow' response, should be moved about in different locations and directions to determine, for example, the areas of highest sound levels, the directionality of the noise field, and the presence of standing waves or interference phenomena.

(a) Steady Noise Measurement

Steady noise is characterized by a relatively constant noise level over a long period of time or during the period of measurement. It may or may not contain audible discrete tones. This type of noise can be determined simply by listening since noise level changes of 1 dB or less cannot be detected while changes of 6 dB or more are quite apparent. Thus, measurements with a sound level meter set on the "slow" response which vary by less than 6 dB may be considered to be measurements of steady noise.

(i) Steady Noise: Using a Sound Level Meter

A Type 2 or better sound level meter which meets

the specifications outlined in section 2(1) may be used to measure noise levels of steady noise with and without audible discrete tones. Noise level readings must be taken with the "slow" response and A- or C-weighting, as appropriate. Any fluctuations in the reading with the instrument operating on the "slow" response must be less than $\pm$ 3 dBA (or dBC) during the entire period of measurement at any one measurement location.

For a specific measurement location and time segment, a minimum of three observations must be made. The observation time for each must be 15 seconds or more. It is advisable that the observations be spaced several minutes apart so that they are representative of noise levels in the entire time segment. For each observation, the average noise level reading (approximated by the mean of the maximum and minimum noise level fluctuations during the observation period) must be noted. The arithmetic mean of the average noise level readings, rounded to the nearest decibel, is the datum to be reported, and shall represent the noise level measurement for the specific location and time segment.

Steady noise with audible discrete tones may lead to a situation where there are large spatial variations in noise level caused by standing waves or interference phenomena. To ensure that measurements of noise level are valid and not influenced by local interferences, the microphone of the sound level meter should be moved a distance of approximately 1 metre about the

measurement position during each observation period.

If the purpose of the noise level measurement is to select a hearing protector and the steady noise has audible discrete tones, a narrow band frequency analysis must be performed, as described in section 3(4)(e).

(ii) Steady Noise: Using a Noise Dosimeter

A noise dosimeter which meets the specifications outlined in section 2(3) may be used in the measurement of steady noise with and without audible discrete tones to provide a value of the percent daily noise dose. In personal exposure measurement of steady noise, a dosimeter is more effective than a sound level meter or an integrating-averaging sound level meter in situations where the worker moves to several locations with different noise levels during the course of his work day.

For a specific time segment, the duration of dosimeter measurement is not critical if the worker is stationary throughout the time segment or if the dosimeter is being used in area noise measurement at a specific location. If the worker is moving throughout the time segment, the duration of dosimeter measurement should be as long as possible, and must represent at least 1/3 of the time segment. The value of the percent daily noise dose must be reported and shall represent the measurement for the specific time

segment and, if relevant, the specific location.

When the measurement instrument is a noise dosimeter, the time segment would typically be the full work day.

(iii) Steady Noise: Using an Integrating-Averaging Sound Level Meter

A Type 2 or better integrating-averaging sound level meter may be used to measure the equivalent sound level (L_{eq}) of steady noise with and without audible discrete tones. Readings must be taken with the A- or C-weighting, as appropriate.

For a specific measurement location and time segment, the instrument must be set to integrate for 1 minute or more. The equivalent sound level (L_{eq}) for the observation, rounded to the nearest decibel, is the datum to be reported, and shall represent the measurement for the specific location and time segment. For steady noise, one observation is sufficient but three observations are preferred. With three observations, the L_{eq} value which is to be reported for the time segment shall be calculated using equation (3.3) on page Mb.22.

For steady noise with audible discrete tones, the precautions regarding standing waves which are specified in section 3(4)(a)(i) must be followed.

(b) Fluctuating and Intermittent Noise Measurement

Fluctuating noise is characterized by a noise level which varies over a range greater than 6 dB (as measured with the "slow" response of a sound level meter) either continuously and erratically or between two or more well-defined steady levels produced, for example, by the cyclic operation of a machine. An intermittent noise is generally produced by sources which cycle on and off; the noise level deviates momentarily and perhaps repeatedly from the ambient or background level at regular or irregular intervals for a time period of one second or more. During the "on" cycle, the intermittent noise may exhibit either fluctuating or steady characteristics.

(i) Fluctuating/Intermittent Noise: Using a Sound Level Meter

A Type 2 or better sound level meter which meets the specifications outlined in section 2(1) may generally be used to measure noise levels of fluctuating and intermittent noise. Noise level readings must be taken with the "slow" response and A- or C-weighting, as appropriate.

For fluctuating noise which varies continuously and erratically, a minimum of three observations must be made for a specific measurement location and time segment. The observation time for each observation shall be 30 seconds or more. The observations must be spaced several minutes apart so that they are representative of noise levels in the entire time segment. For each observation, the maximum and minimum noise

level readings during the observation period must be noted. The mean indication of the meter does not correspond to the average noise level reading because of the nature of addition of logarithmic quantities so the average noise level reading must be determined as follows:

- If the total range of meter fluctuation during the observation period is between 6 and 10 dB, the average noise level reading for the observation shall be approximated to be 3 dB below the maximum reading. If successive fluctuations are observed to have different maximum levels, the average noise level reading for the observation shall be approximated to be 3 dB below the mean of the maximum levels.

- If the total range of meter fluctuation during the observation period is greater than 10 dB, the average noise level reading for the observation, L_{obs}, shall be obtained from several readings taken at approximately equal time intervals of two seconds or more, using the following equation:

$$L_{obs} = 10 \log_{10} \cdot \frac{1}{N} \sum_{i=1}^{N} 10^{0.1 L_i}$$

(Equation 3.1)

where N is the number of readings for the observation, and L_i is the level at each reading. The number of readings should be 10 or more; it is accepted practice to obtain a number of readings which equals the total range of the noise fluctuations in decibels.

If the difference between any two average noise level readings is greater than 6 dB, a minimum of six observations must be made. The average noise level, L_s, for the period of measurement shall be calculated from the observations as follows:

$$L_s = 10 \log_{10} \sum_{i=1}^{n} \frac{t_i}{T_m} 10^{0.1 L_{obs,i}}$$

(Equation 3.2)

where t_i is the observation time and $L_{obs,i}$ is the average noise level reading for an observation, n is the number of observations, and T_m is the total measurement period which equals the sum of the observation times. The value of L_s, rounded to the nearest decibel, is the datum to be reported, and shall represent the noise level measurement for the specific location and time segment.

For fluctuating noise which varies between two or more well-defined steady values, the noise level at each steady value must be determined and reported, using the method specified in section 3(4)(a)(i) for steady noise. An estimate of the total time intervals for the different steady values must also be obtained, and these shall be considered to be separate time segments.

For intermittent noise, the noise level during the "on" cycle must be determined and reported. The method specified in this section or in section 3(4)(a)(i) must be used, depending on whether the

intermittent noise exhibits fluctuating or steady characteristics during the "on" cycle. An estimate of the time intervals for the "on" and "off" cycles must also be obtained, and these shall be considered to be separate time segments.

The use of a Type 2 sound level meter operating on the "slow" response is inadvisable if the fluctuating or intermittent noise has a significant impulse component. The presence of a significant impulse component in the fluctuating or intermittent noise may be deduced from preliminary observations using the "fast" response of the sound level meter. Another test is to compare the readings obtained with the A-weighted "fast" response and the A-weighted "slow" response of a sound level meter. If the difference in these readings is significant (5 to 10 dBA), the fluctuating or intermittent noise might be judged to have a significant impulse component with impulse durations less than 300 milliseconds, and the methods outlined in section 3(4)(c) for impulse noise must be followed.

(ii) Fluctuating/Intermittent Noise: Using a Noise Dosimeter

A noise dosimeter which meets the specifications outlined in section 2(3) may generally be used in the measurement of fluctuating and intermittent noise to provide a value of the percent daily noise dose. In personal exposure measurement of fluctuating and intermittent noise, a dosimeter is more effective than a sound level meter or

integrating-averaging sound level meter in situations where noise levels vary throughout the time segment either in time, as is the case for fluctuating or intermittent noise, or in location if the worker moves about during the course of his work.

For a specific time segment and, if relevant, a specific location (when the instrument is used in area noise measurement) the duration of dosimeter measurement should be as long as possible, and must represent at least 1/3 of the time segment. The value of the percent daily noise dose must be reported and shall represent the measurement for the specific time segment and, if relevant, the specific location.

When the measurement instrument is a noise dosimeter, the time segment would typically be the full work day.

Care must be exercised in a dosimetry measurement if the fluctuating or intermittent noise is suspected to have a significant impulse component, since the noise dosimeter is basically an integrating noise measuring device with a "slow" response. If there is a significant impulse component, the noise dosimeter should be used only if it is specified by the manufacturer for the measurement of impulse noise. The dosimeter must have an adequately high crest factor capability of at least 10 dB, or otherwise sufficient to meet the requirements of the measurement.

(iii) Fluctuating/Intermittent Noise: Using an Integrating-Averaging Sound Level Meter

A Type 2 or better integrating-averaging sound level meter may generally be used to measure the equivalent sound level (L_{eq}) of fluctuating and intermittent noise. In both area and personal exposure measurement of fluctuating and intermittent noise, an integrating-averaging sound level meter is more effective in determining the L_{eq} value than a conventional sound level meter, since the former takes many more readings at frequent intervals and does the averaging automatically, thus yielding a more accurate result. Readings must be taken with the A- or C-weighting, as appropriate.

For a specific measurement location and time segment, a minimum of three observations must be made. For each observation, the instrument must be set to integrate for one minute or more. The observations must be spaced several minutes apart so that they are representative of noise levels in the entire time segment. If the difference between any two equivalent sound level (L_{eq}) readings is greater than 6 dB, a minimum of six observations must be made. The equivalent sound level (L_{eq}) value for the period of measurement $L_{eq,s}$ must be calculated from the observations as follows:

$$L_{eq,s} = 10 \log_{10} \sum_{i=1}^{n} \frac{t_i}{T_m} \; 10^{0.1 L_{eq,i}}$$

(Equation 3.3)

where t_i is the observation time and $L_{eq,i}$ is the equivalent sound level reading for an observation, n is the number of observations, and T_m is the total measurement period which equals the sum of the observation times. The value of $L_{eq,s}$ rounded to the nearest decibel, is the datum to be reported, and shall represent the equivalent sound level for the specific location and time segment.

If the integrating-averaging sound level meter which is used is capable of integrating for long periods of time (minutes to several hours) in a continuous measurement mode, the above-mentioned measurement procedure may be replaced by a single observation of appropriate duration. The L_{eq} value for the observation, rounded to the nearest decibel, is the datum to be reported, and shall represent the measurement for the specific location and time segment.

If there is a signficant impulse component, the integrating-averaging sound level meter should be used only if it is specified by the manufacturer for the measurement of impulse noise. The instrument must have an adequately high crest factor capability of at least 10 dB, or otherwise sufficient to meet the requirements of the measurement.

(c) Impulse Noise Measurement

Impulse noise is characterized by brief excursions of sound pressure which significantly exceed the ambient

sound pressure. There are two sub-categories of impulse noise:

Isolated Impulses: The noise consists of a single pressure pulse or a single burst (multiple pressure pulses) having a duration less than one second with an interval between pulses or bursts greater than one second.

Quasi-Steady Noise: The noise consists of a train of pulses or bursts with the duration of each pulse or burst being less than one second. The individual pulses or bursts may have equal or unequal amplitudes and/or spacing. The time interval between individual pulses or bursts is one second or less, and prevents their detailed resolution with a sound level meter operating with the "slow" response.

(i) Impulse Noise: Using a Sound Level Meter

Isolated Impulses

For isolated impulses, a measurement of the peak sound pressure is required to ensure compliance with a ceiling standard of 135 dB. The peak sound pressure of isolated impulses must be measured with a Type 1 sound level meter which meets the specifications outlined in section 2(1). Readings must be taken with the "peak" response.

For a specific measurement location and time segment, a minimum of 10 impulses must be measured. For each impulse, the peak sound

pressure must be determined, and the average peak sound pressure, $L_{I,avg}$, must be calculated as follows:

$$L_{I,avg} = 10 \log_{10} \frac{1}{N} \sum_{i=1}^{N} 10^{0.1 L_{I,i}}$$

(Equation 3.4)

where $L_{I,i}$ is the peak sound pressure of each impulse and N is the number of impulses. The value of $L_{I,avg}$, rounded to the nearest decibel, is the datum to be reported, and shall represent the peak sound pressure measurement for the specific measurement location and time segment.

Quasi-Steady Noise

A Type 1 sound level meter which meets the specifications outlined in section 2(1) may be used to measure the noise levels of quasi-steady noise. The instrument must have an adequately high crest factor capability of at least 10 dB, or otherwise sufficient to meet the requirements of the measurement. Noise level readings must be taken with the "slow" response and A- or C-weighting, as appropriate.

For a specific measurement location and time segment, the measurement procedure outlined in section 3(4)(a)(i) for steady noise must be used if the observed fluctuations in the sound pressure level, with the instrument operating on the "slow" response, are less than $\pm$ 3 dBA (or dBC). If the fluctuations in the sound pressure level are

greater than 6 dBA (or dBC), the measurement procedure outlined in section 3(4)(b)(i) must be used. The datum reported shall represent the noise level measurement for the specific location and time segment.

(ii) Impulse Noise: Using a Noise Dosimeter

A noise dosimeter which meets the specifications outlined in section 2(3) may be used for both isolated impulses and quasi-steady noise to measure the percent daily noise dose provided it is specified by the manufacturer for the measurement of impulse noise. The instrument must have an adequately high crest factor capability of at least 10 dB, or otherwise sufficient to meet the requirements of the measurement.

For a specific time segment and, if relevant, a specific location (when the instrument is used in area noise measurement), the measurement procedure outlined in section 3(4)(b)(ii) must be used. The value of the percent daily noise dose is the datum to be reported.

(iii) Impulse Noise: Using an Integrating-Averaging Sound Level Meter

A Type 1 integrating-averaging sound level meter

may be used for both isolated impulses and quasi-steady noise to obtain a measurement of the equivalent sound level (L_{eq}), provided it is specified by the manufacturer for the measurement of impulse noise. The instrument must have an adequately high crest factor capability of at least 10 dB, or otherwise sufficient to meet the requirements of the measurement. It must also be capable of integrating for extended time periods of at least several minutes. Readings must be taken with the A- or C-weighting, as appropriate.

Isolated Impulses

For a specific measurement location and time segment, the instrument must be set to integrate for an appropriate time period so that a minimum of 20 impulses will be measured within a continuous period of 20 minutes. The L_{eq} value for the period of measurement, rounded to the nearest decibel, is the datum to be reported and shall represent the measurement for the specific location and time segment.

Quasi-Steady Noise

For a specific measurement location and time segment, the measurement procedure outlined in section 3(4)(b)(iii) must be used. Alternatively, the measurement procedure outlined in section 3(4)(a)(iii) for steady noise may also be used if it is verified that the fluctuations in sound pressure level, as measured with the "slow" response of a

Type 1 sound level meter, are less than ± 3 dBA (or dBC). The datum reported shall represent the L_{eq} value for the specific location and time segment.

(d) Weighted Noise Level Measurements

Noise level measurements must be carried out with the A-weighting network of a sound level meter or integrating-averaging sound level meter to determine the need for a hearing conservation program or to evaluate a worker's noise exposure. Noise level measurements must be carried out with the C-weighting network of a sound level meter or integrating-averaging sound level meter to select an appropriate hearing protector by the procedures outlined in the Code for Hearing Protection of Noise-Exposed Workers. Noise level measurements may alternatively be taken with the "unweighted" or "linear" setting of the instrument if it does not possess a C-weighting network.

(e) Spectral Analysis

Measurements of the noise levels in octave bands with center frequencies at 250, 500, 1000, 2000, 4000 and 8000 Hz are required in the selection of an appropriate hearing protector as outlined in the Code for Hearing Protection of Noise-Exposed Workers. Measurements of the sound pressure levels in octave bands and/or third-octave bands with center frequencies in the range of 250 to 8000 Hz are required in the assessment of background sound levels in audiometric sound-proof booths, as outlined in the Code for Audiometry of Noise-Exposed Workers.

Octave and third-octave band noise level measurements must be carried out with a Type 2 or better sound level meter or integrating-averaging sound level meter, equipped with the appropriate octave or third-octave band filter set which meets the specifications outlined in section 2(2). Noise level measurements must be carried out with the A- or C-weighting, as appropriate.

Where required, the overall A- or C-weighted noise level, $L_{overall,}$ may be calculated respectively from the A- or C-weighted band noise level measurements (octave or third-octave) as follows:

$$L_{overall} = 10 \log_{10} \sum_{\substack{\text{measured} \\ \text{bands}}} 10^{0.1 L_{B,i}}$$

(Equation 3.5)

where $L_{B,i}$ is the octave or third-octave band noise level measurement.

4. Compliance Calculations

The noise regulation specifies that a hearing conservation program must be implemented if a worker is likely to be exposed to noise in excess of an 85 dBA sound level and that the health of the worker may be affected thereby, and in any event where the worker is exposed to noise in excess of an 85 dBA sound level for 20 hours or more in a work week. Only the noise level data and/or 1 minute L_{eq} data from area noise measurement, obtained as discussed in section 3(1), are to be used in this calculation.

The equivalent sound exposure level, L_{ex}, may be calculated from any of the following data:

- noise level data obtained with a sound level meter
- percent daily noise dose data obtained with a noise dosimeter,
- equivalent sound level data, (L_{eq}) obtained with an integrating-averaging sound level meter.

In the calculation of L_{ex}, only the data from personal exposure measurement, obtained with the worker present as discussed in section 3(3), are to be used. It must also be recognized that a noise dosimeter may yield values of L_{ex} which are up to 3 dBA higher than those determined by using a sound level meter. This must be taken into consideration when evaluating noise exposures.

(1) Calculation of L_{ex} from Sound Level Data

The equation for equivalent sound exposure level, L_{ex}, is:

$$L_{ex} = 10 \log_{10} \sum_{\substack{\text{all time} \\ \text{segments}}} \frac{T_{s,i}}{40} \; 10^{0.1 L_{s,i}}$$

where $\sum T_{s,i} = T_w$; the number of hours in a work week

(Equation 4.1)

In equation 4.1, the time segment $T_{s,i}$ is the total duration in hours per work week that the noise level is $L_{s,i}$, and the sum is over all time segments in the work week of T_w hours. It should be noted that the sum of the time segments does not

necessarily equal the criterion duration of 40 hours. For example, the worker may work overtime and be exposed to significant noise for more than 40 hours in a work week, as illustrated in Example 1. Alternatively, there may be time segments in which the worker is not exposed to noise, as illustrated in Example 2, and the contribution of these time segments to L_{ex} is negligible.

Summary of Method

1. Measure the noise level in dBA to which the worker is exposed, for each characteristic time segment of a work week in which the noise environment is relatively uniform and of a specific character.

2. Determine the duration of each time segment in hours per work week.

3. Calculate L_{ex} using equation 4.1.

Example 1: In 1 work week, a worker's exposure to noise is as follows:

	T_i (hrs.)	L_i (dBA)
	7.5	100
	10	90
	10	93
	4	85
	5	less than 80
	9.5	105
Total	46 hours	

Using equation 4.1:

$$L_{ex} = 10 \log_{10} \left(\frac{1}{40} \left(7.5\times10^{10} + 10\times10^{9} + 10\times10^{9.3} + 4\times10^{8.5} + 5 \times 10^{8} + 9.5 \times 10^{10.5}\right)\right)$$
$$= 100 \text{ dBA}$$

Example 2: In 1 work week, a worker's exposure to noise is follows:

	T_i (hrs.)	L_i (dBA)
	7.5	100
	10	90
	10	93
	4	85
	5	less than 80
Total	36.5	

Using equation 4.1:

$$L_{ex} = 10 \log_{10} \left(\frac{1}{40} \left(7.5\times10^{10} + 10\times10^{9} + 10\times10^{9.3} + 4\times10^{8.5} + 5\times10^{8}\right)\right)$$
$$= 94 \text{ dBA}$$

(2) Calculation of L_{ex} from Dosimeter Data of Percent Daily Noise Dose

A noise dosimeter is usually operated on a day-to-day basis. It has a time basis and sound level basis of 8 hours and 90 dB respectively, such that an exposure to a steady noise level of 90 dBA for 8 hours produces a percent daily noise dose of 100%.

However, notwithstanding these operational characteristics, the equivalent sound exposure level, L_{ex}, must be determined for a time basis of 40 hours per work week. Therefore, the calculation of L_{ex} from dosimeter data of percent daily noise dose is based on the following approach:

- Because the dosimeter operates one day at a time with a time basis of 8 hours and a sound level basis of 90 dB, it is valid to convert the percent daily noise dose measurement for a given day into an equivalent 8 hour time-weighted average noise level (TWA). The TWA value is the A-weighted noise level which, if constant over an 8 hour duration, would result in the same percent daily noise dose that the dosimeter would measure for the time-varying noise that a worker is exposed to in 1 work day. The relationship between TWA and the percent daily noise dose D is

$$TWA = 10 \log_{10} \left(\frac{D}{100}\right) + 90$$

(Equation 4.2)

where D is in %. The relationship between D and TWA, as calculated from equation 4.2, is given in Table 4.1.

- The value of TWA for a given work day, as converted from the D measurement for the same work day, represents a noise level to which a worker is exposed for 8 hours. Thus, the TWA values for all the work days in a work week can be used to calculate L_{ex} using equation 4.1

Summary of Method

1. Measure the percent daily noise dose for the worker for each characteristic time segment of a work week in which the noise environment is relatively uniform and of a specific character.

2. Determine the duration of each time segment in hours per work week.

3. Determine the percent daily noise dose for each work day in a work week that the noise environment is different. Only one day needs to be investigated if the noise environment is the same from day to day. Because dose values are based on energy and energy is an additive quantity, the percent daily noise dose for each work day is a sum of the individual dosimeter measurements for each time segment of that day.

4. Convert the percent daily noise dose values to TWA vasents a noise level to which a worker is exposed for 8 hours. Thus, the TWA values for all the work days in a work week can be used to calculate L_{ex} using equation 4.1.

Summary of Method

1. Measure the percent daily noise dose for the worker for each characteristic time segment of a work week in which the noise environment is relatively uniform and of a specific character.

2. Determine the duration of each time segment in hours per work week.

3. Determine the percent daily noise dose for each work day in a work week that the noise environment is different. Only one day needs to be investigated if the noise environment is the same from day to day. Because dose values are based on energy and energy is an additive quantity, the percent daily noise dose for each work day is a sum of the individual dosimeter measurements for each time segment of that day.

4. Convert the percent daily noise dose values to TWA values for each work day of a work week.

5. Using each TWA value as a noise level value with a duration of 8 hours, calculate L_{ex} using equation 4.1.

Example 3: Dosimeter measurements taken in 1 work day which is typical of every day in a work week are as follows:

Time segment #1 - Noise environment is relatively uniform and of a specific character.

Exposure time = 3 hours
Sampling time = 2 hours
Dosimeter reading (2 hrs.) = 80%

Extrapolated dosimeter reading (3 hrs.) = $\frac{3}{2}$ x 80 % = 120 %

Time segment #2 - Noise environment is relatively uniform and of a specific character:

Exposure time = 4 hours
Sampling time = 2 hours
Dosimeter reading (2 hrs.) = 98%

Extrapolated dosimeter reading (4 hrs.) = $\frac{4}{2}$ x 98 % = 196 %

Percent daily noise dose = 120 + 196 = 316 %

From table 4.1 or equation 4.2, the TWA value for the work day = 95 dBA

Because the noise environment is the same from day to day, the TWA value for every work day is 95 dBA.

Using equation 4.1,

$$L_{ex} = 10 \log_{10} \left(\frac{1}{40} \left(8 \times 10^{9.5} + 8 \times 10^{9.5} + 8 \times 10^{9.5} + 8 \times 10^{9.5} + 8 \times 10^{9.5}\right)\right)$$

$$= 95 \text{ dBA}$$

Example 4: Dosimetry measurements are taken in every day of the work week because the noise environment changes from day to day.

Day	Measured Percent Daily Noise Dose (in %)	TWA from Table 4.1 or equation (4.2) (in dBA)
#1	1000	100
#2	100	90
#3	200	93
#4	32	85
#5	316	95

Using equation 4.1,

$$L_{ex} = 10 \log_{10} \left(\frac{1}{40} \left(8 \times 10^{10} + 8 \times 10^{9} + 8 \times 10^{9.3} + 8 \times 10^{8.5} + 8 \times 10^{9.5}\right)\right)$$

$$= 95 \text{ dBA}$$

(3) Calculation of L_{ex} from L_{eq} Data Obtained with an Integrating-Averaging Sound Level Meter

The L_{eq} measurement is, in essence, an A-weighted noise level of an equivalent steady noise for the period of measurement. It is necessary to identify the time segment in which the noise environment is the same as that measured. The value of L_{ex} can then be calculated using equation 4.1.

A useful relationship for the calculation of an overall L_{eq} value for one work day is:

$$L_{eq}(1\ \text{day}) = 10 \log_{10} \sum_{\substack{\text{all time} \\ \text{segments}}} \frac{T_{s,i}}{T_d} \; 10^{0.1\, L_{eq,s,i}}$$

(Equation 4.3)

where $\sum T_{s,i} = T_d$; the number of hours in a work day.

In equation 4.3, $L_{eq,s,i}$ and $T_{s,i}$ are respectively the L_{eq} values in dBA and durations in hours of the separate time segments in the work day in which the noise environment is different.

Summary of Method

1. Measure the equivalent sound level (L_{eq}) for each characteristic time segment of a work week in which the noise environment is relatively uniform and of a specific character.

2. Determine the duration of each time segment in hours per work week.

3. Using each L_{eq} value as a noise level, calculate L_{ex} using equation 4.1.

Example 5: Worker works for 4 days. The L_{eq} measurements taken in 1 work day which is typical of every day in the week are as follows:

Time Segment #1: - Noise environment is relatively uniform and of a specific character.

Exposure time = 3 hours
Sampling time = 1 minute
L_{eq} (1 min.) = 93 dBA

Time Segment #2: - Noise environment is relatively uniform and of a specific character.
Exposure time = 4 hours
Sampling time = 1 minute
L_{eq} (1 min.) = 96 dBA

If 1 minute sampling in each time segment is adequate to define the noise environment in that time segment:

For time segment #1: L_{eq} (3 hrs.) = 93 dBA
For time segment #2: L_{eq} (4 hrs.) = 96 dBA

From equation 4.3:

$$L_{eq}(7 \text{ hrs.}) = 10 \log_{10}\left(\frac{1}{7}\left(3 \times 10^{9.3} + 4 \times 10^{9.6}\right)\right) = 95 \text{ dBA}$$

Because the noise environment is the same from day to day, the L_{eq} value for every work day is L_{eq} (7 hrs.) = 95 dBA.

Using equation 4.1,

$$L_{ex} = 10 \log_{10}\left(\frac{1}{40}\left(7 \times 10^{9.5} + 7 \times 10^{9.5} + 7 \times 10^{9.5} + 7 \times 10^{9.5}\right)\right)$$
$$= 93 \text{ dBA}$$

5. Records

The following information should be included in noise measurements records.

(1) General

(a) As appropriate, the company, plant, department, process, operation, plant section, and work station.

(b) Identity of investigator.

(c) Date and time when measurements were performed.

(2) Noise Environment

(a) Location and description of the relevant noise sources, using a dimensioned sketch if necessary.

(b) Qualitative description of the type of noise.

(c) The time segments of noise exposure.

(d) As appropriate, a description of the physical layout of the relevant work areas, using a dimensioned sketch if necessary (e.g. size and shape of room, location of work stations, locations of barriers and enclosures, types of surface materials, and existing acoustical treatment).

(3) Instrumentation

(a) The instruments used to carry out measurements, including the microphones, filter sets, acoustic calibrators and extension cables or rods identified by name, type, model, serial number, and manufacturer.

(b) Operational information including calibration and battery check data.

(4) Data for Area Noise Measurement

(a) Measurement details such as instrument setting, instrument configuration, and environmental conditions.

(b) Measurement locations and time segments.

(c) Area noise readings per section 3(3)(m) with durations of measurement, treatment of data, and values of noise levels preferably listed in tabular form and referenced to measurement locations and time segments.

(d) A comparison of noise levels with the standard specified in the noise regulation, and action taken.

(5) Data for Personal Exposure Measurement

(a) Identity of worker by name and job category and description of his work pattern.

(b) Measurement details such as instrument setting, instrument configuration, and environmental conditions.

(c) The worker's locations when measurements are taken and time segments.

(d) Personal exposure readings per section 3(3)(m) with durations of measurement, treatment of data, and personal exposure values (consisting of noise level data, percent daily noise dose data, and L_{eq} data), preferably listed in tabular form and referenced to time segments and, if applicable, worker's locations.

(e) The calculation of the equivalent sound exposure level, L_{ex}, for the worker.

(f) A comparison of the calculated value of L_{ex} with the standard specified in the noise regulation, and action taken.

APPENDIX

Glossary

Crest factor - The ratio of the peak value and the root-mean-square value measured over a specified time interval where both values are measured in reference to the arithmetic mean value of the wave.

Criterion daily duration - A duration of 8 hours which is used as the time basis for measurement by a dosimeter.

Criterion daily noise exposure - The product of the criterion daily duration (8 hours), and the mean-square sound pressure corresponding to the criterion noise level (90 dB).

Criterion duration - 40 hours in one work week.

Criterion noise exposure - The product of the criterion duration (40 hours) and the mean-square sound pressure corresponding to the criterion noise level (90 dB).

Criterion noise level - A noise level of 90 dB which is the basis for measurement by a noise dosimeter. It is the steady level in dB at which an 8 hour exposure produces a percent daily noise dose of 100%.

Decibel (dB) - Dimensionless unit of sound level and sound pressure level.

Decibel A-weighted (dB A) - Unit of sound pressure level modified by A-weighting.

Equivalent sound level (L_{eq}) - The A-weighted sound level in dBA of a steady sound which contains the same total acoustic energy integrated

over a specified time period as the actual time-varying sound of interest. The time period may be specified in brackets as in the following examples: L_{eq} (1 min.) or L_{eq} (2 hrs.).

Equivalent sound exposure level, L_{ex} - The steady sound level in dBA which, if present for 40 hours in one work week, would contain the same total acoustic energy as that generated by the actual and varying sound levels to which a worker is taken to be exposed in one work week.

Exchange rate - The number of dB increase or decrease which causes the exposure time to be respectively halved or doubled, if the sound exposure is to remain unchanged. For the noise regulation, the exchange rate is 3 dB.

Percent daily noise dose - The ratio of the noise exposure and the criterion daily noise exposure, expressed in percent.

Percent noise dose - The ratio of the noise exposure and the criterion noise exposure, expressed in percent.

Noise exposure - The time integral, over a stated time or event, of the "slow", exponential time-averaged, squared, A-weighted, sound pressure signal.

Noise level - The A- or C-weighted sound pressure level.

Sound pressure level - 20 times the logarithm to the base 10 of the ratio of the root mean square (rms) pressure of a sound to the root mean square of the reference pressure using a reference of 20 micropascals.

Time-weighted-average (TWA) noise level - The A-weighted noise level which, if constant over an 8 hour duration, would result in the same percent daily noise dose as is measured with a dosimeter or calculated from noise level measurements.

Table 4.1 - Conversion From Percent Daily Noise Dose (D) to 8-hour Time-Weighted Average Noise Level (TWA)

D (%)	TWA (dBA)	D (%)	TWA (dBA)	D (%)	TWA (dBA)	D (%)	TWA (dBA)	D (%)	TWA (dBA)
10	80.0	110	90.4	220	93.4	450	96.5	950	99.8
20	83.0	120	90.8	240	93.8	500	97.0	1000	100.0
30	84.8	130	91.1	260	94.1	550	97.4	1200	100.8
40	86.0	140	91.5	280	94.5	600	97.8	1400	101.5
50	87.0	150	91.8	300	94.8	650	98.1	1600	102.0
60	87.8	160	92.0	320	95.1	700	98.5	1800	102.6
70	88.5	170	92.3	340	95.3	750	98.8	2000	103.0
80	89.0	180	92.6	360	95.6	800	99.0	2200	103.4
90	89.5	190	92.8	380	95.8	850	99.3	2400	103.8
100	90.0	200	93.0	400	96.0	900	99.5	2600	104.1

MEDICAL SURVEILLANCE PROGRAM

1. Purpose

The objective of a medical surveillance program is to protect the health of workers by:

(1) evaluating the hearing of a worker;

(2) assessing a worker's fitness to continue in exposure;

(3) enabling remedial action to be taken in respect of the worker and the environment when necessary;

(4) providing health education.

2. Program

The medical surveillance program must consist of the following:

(1) Pre-employment and pre-placement examinations;

(2) Periodic medical examinations;

(3) Audiometric tests;

(4) Health education;

(5) Record keeping.

3. Medical Examinations

The medical examination and clinical tests conducted by the

physician or under his direction must include the following:

(1) History

The initial medical and occupational history must include enquiry for previous exposure to noise (both occupational and non-occupational) and a history of present or past ear and hearing disorders. At the periodic examination the history must be updated to include:

(a) history of frequency and duration of exposure to noise since previous examination;

(b) enquiry for signs and symptoms that may be an early indication of a hearing impairment or ear defect.

(2) Physical Examination

An otoscopic examination is required.

4. **Audiometric Tests**

An initial audiometric test aids in the assessment of a worker's fitness for work, and in the detection of non-work related ear disease. Periodic tests will permit the detection of any deterioration in hearing, and consideration of the need to modify the type of hearing protection or extent of noise exposure.

Audiometry must be of sufficiently high quality to provide reliable tests results. Guidance on instruments suitable for industrial screening, and their use is given in the Code for Audiometry.

(1) Action Levels

Any significant confirmed deterioration in hearing from previous tests, e.g. 10 dB or more at any one frequency, 5 dB or more average over three adjacent frequencies, must be evaluated by the company physician, the noise exposure reassessed and the worker counselled. If the cause and diagnosis is uncertain, further otological investigation must be sought.

Workers with a noise induced hearing threshold average of 25 dB at 0.5, 1, 2 and 3 kHz in either ear should be referred for Workmen's Compensation Board assessment.

If the worker has sustained a noise induced hearing loss a determination must be made by the physician as to whether the worker is fit with limitations or unfit and action taken in accordance with Section 16 of the Noise Regulation.

5. Health Education

All workers must be made aware of the hazard from noise, the precautions to be taken to prevent hearing loss, and the proper care and use of hearing protectors. Quiet rooms provided as hygiene facilities under a hearing conservation program should be used during break periods.

Their examination results must be discussed.

6. Medical History and Examination Records

Under the provisions of the noise regulation the examining physician must maintain health records for each worker examined. Such records should include:

- name in full of the worker;

- maiden surname of mother;
- date of birth;
- sex;
- Social Insurance Number;
- the type of noise: continuous, intermittent, impact;
- occupational or job titles of worker;
- date occupations or jobs commenced;
- date occupations or jobs ended;
- the kinds of operations or processes in which the worker is involved;
- noise levels and length of exposure per shift;
- use of hearing protectors;
- dates of visits to physician's office;
- medical examination reports;
- health assessments;
- records of audiometric tests;
- copies of referral letter to a hospital or physician;
- copies of Forms 7 and 8 of Workmen's Compensation Board if completed;
- all relevant information concerning health, and any information concerning the actions taken in response to abnormal audiometric tests.

A worker's health records must be kept in a secure place by the examining physician for:

(1) a period of forty years from the time such records were first made, or

(2) a period of twenty years from the time the last of such records were made,

whichever is the longer.

Where the examining physician or his successor is no longer able or willing to keep the records, the records are to be forwarded to the Chief Physician, Occupational Health Medical Service of the Ministry, who will keep them in a secure place.

APPENDIX Nb

CODE FOR MEDICAL SURVEILLANCE OF NOISE-EXPOSED WORKERS

MINISTRY OF LABOUR
OCCUPATIONAL HEALTH AND SAFETY DIVISION
November 23, 1981

MEDICAL SURVEILLANCE PROGRAM

1. Purpose

The objective of a medical surveillance program is to protect the health of workers by:

(1) ensuring fitness for exposure to noise;

(2) evaluating the effect of noise on workers;

(3) enabling remedial action to be taken when necessary; and

(4) providing health education.

2. Program

The medical surveillance program must consist of the following:

(1) pre-placement examinations;

(2) periodic examinations;

(3) audiometric tests;

(4) health education; and

(5) record keeping.

3. Medical Examinations and Clinical Tests

The frequency of the medical examinations and clinical tests will depend on the intensity and length of exposure to noise, and should be

decided by the examining physician.

The medical examinations and clinical tests conducted by the physician or under his direction must include the following:

(1) History

The initial medical and occupational histories must include enquiry for previous exposure to noise (both occupational and non-occupational) and a history of present or past ear and hearing disorders. Periodically the history must be updated to include:

(a) history of frequency and duration of exposure to noise since previous audiometric test; and

(b) enquiry for signs and symptoms that may be an early indication of a hearing impairment or ear defect.

(2) Physical Examination

An initial otoscopic examination is required to identify pathology when the audiometric test reveals a hearing threshold level below that considered to be normal for the age of the worker, or when there has been a significant deterioration in hearing from the baseline and subsequently at the discretion of the physician.

(3) Clinical Tests

(a) Audiometry

Audiometric tests must be undertaken in facilities that meet the requirements of the Code for Audiometry of

Noise-Exposed Workers.

An initial audiometric test aids in the assessment of the fitness of a worker for work in noise, and in the detection of non-work related ear diseases. Periodic tests will permit the detection of any deterioration in hearing, and consideration of the need to modify the type of hearing protection or extent of noise exposure. The tests must be carried out at least on a biennial basis, or more often when an employee shows a significant change in hearing level.

(b) Action Levels

Any confirmed significant threshold shift from the baseline or more recent audiogram in either ear must be reviewed by the examining physician, the noise exposure and hearing protection reassessed and the worker counselled. If the cause and diagnosis is uncertain, further otological investigation must be sought.

Workers with a confirmed hearing loss of 25 dB average at 0.5, 1, 2 and 3 kHz in both ears should be referred for Workmen's Compensation Board assessment, if the hearing loss is thought to be occupationally induced. A determination must be made by the physician as to whether the worker is fit with limitations or unfit and action taken in accordance with Section 16 of the Noise Regulation.

(c) Reporting

The audiograms must be read by the physician, or an audiologist or audiometric technician working under his

direction. The physician should provide the joint health and safety committee with an annual report, summarizing the results of audiometric tests.

4. Health Education

All workers must be made aware of the hazard from noise, the precautions to be taken to prevent hearing loss, and the proper care and use of hearing protectors. During break periods, workers must be encouraged to use quiet rooms (less than 80 dBA) provided as hygiene facilities under a hearing conservation program.

The results of the examinations and clinical tests must be discussed with the worker to provide explanation and reassurance as necessary.

5. Medical History and Examination Records

Under the provisions of the Noise Regulation the examining physician must maintain health records for each worker examined. Such records should include:

- name in full of the worker;
- maiden surname of mother;
- date of birth;
- sex;
- Social Insurance Number;
- the type of noise: continuous, intermittent, impact;
- occupational or job titles of worker;
- date occupations or jobs commenced;
- date occupations or jobs ended;
- the kinds of operations or processes in which the worker is involved;
- noise levels and length of exposure per shift;
- use of hearing protectors;

- dates of visits to physician's office;
- medical examination reports;
- health assessments;
- records of audiometric tests;
- copies of referral letter to a hospital or physician;
- copies of Forms 7 and 8 of Workmen's Compensation Board, if completed;
- all relevant information concerning health, and any information concerning the actions taken in response to abnormal audiometric tests.

A worker's health records must be kept in a secure place by the examining physician for:

(1) a period of forty years from the time such records were first made, or

(2) a period of twenty years from the time the last of such records were made,

whichever is the longer.

Where the examining physician or his successor is no longer able or willing to keep the records, the records are to be forwarded to the Chief Physician, Occupational Health Medical Service of the Ministry, who will keep them in a secure place.

APPENDIX Mc

CODE FOR NOISE MEASUREMENT

MINISTRY OF LABOUR
OCCUPATIONAL HEALTH AND SAFETY DIVISION
November 5, 1982

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NOISE MEASUREMENT

1. Purpose

(1) To identify the areas where hearing protection equipment and engineering controls are needed.

(2) To assist in the determination as to whether a hearing conservation program is required.

(3) To satisfy the provisions of a hearing conservation program.

2. Instrumentation

(1) Sound Level Meter - A sound level meter is an instrument which measures sound pressure levels with a frequency weighting and a time characteristic. The sound level meter, including the microphone, must meet the performance requirements of the International Electrotechnical Commission (IEC) Standard IEC 651-1979 "Sound Level Meters".

For the purposes of this code, a sound level meter must have the following characteristics defined in the standard:

(a) Type 1 or Type 2 tolerances.

(b) A minimum operating range extending from 80 to 130 dBA (or dBC). The operating range of a sound level meter is defined as the range between the lower and upper sound levels within which the instrument operates linearly within tolerances specified in the standard. For measurements of background sound levels in audiometric sound-proof booths, the operating range must extend to 30 dBA. For measurements of sound pressure levels of isolated impulses,

the operating range must extend to 140 dBA.

(c) An A - and/or C - weighting frequency characteristic, as appropriate (see section 3(3)(d)). An optional frequency weighting characteristic designated as "Lin", "Linear" or "Flat", when provided, can be a substitute for the C-weighting.

(d) Time weighting characteristics designated as "slow" and "fast". An "impulse" characteristic is required for the measurement of isolated impulses.

(e) For the measurement of impulse noise, an adequately high crest factor capability of at least 10 dB or otherwise sufficient to meet the requirements of the measurement.

(2) Octave and Third - Octave Band Filter Sets - Octave and third - octave band filter sets are used with a sound level meter or an integrating-averaging sound level meter to measure sound levels in specific frequency bands. These instruments must meet the performance requirements of the Canadian Standards Association (CSA) Standard Z107.5-1975 "Octave, Half-Octave, and Third-Octave Band Filter Sets."

For the purposes of this code, an octave band filter set must have a range of filter bands designated as Type E (extended range), and minimum performance specifications designated as Class I or II. A third-octave band filter set must have Type E (extended range) and Class II or III designations.

(3) Noise Dosimeter - A noise dosimeter is an instrument which directly integrates a function of the sound pressure over a period of time to provide a measure of the percent daily noise dose. Thus, a dosimeter is useful in the assessment of worker exposure in situations

where the sound levels vary throughout the work shift either in time, as for non-steady noise, or in location if the worker is mobile. Although a dosimeter gives a time-integrated result, it can be used to give a short-term measurement if it is set to integrate for one minute or less. The noise dosimeter including the microphone, must meet the performance requirements of the American National Standards Institute (ANSI) standard ANSI S1.25-1978 "Specification for Personal Noise Dosimeters", pending the publication of an IEC standard for personal sound exposure meters (dosimeters).

For the purposes of this code, a noise dosimeter must have the following characteristics defined in the standard:

(a) A type 2 tolerance as specified in IEC 651-1979 for sound level meters;

(b) An A - weighting frequency characteristic;

(c) A time weighting characteristic designated as "slow";

(d) A criterion sound level of 90 dB at which an 8 hour per day exposure yields 100% of the criterion daily noise exposure;

(e) A threshold level of 80 dB;

(f) A capability to integrate for one minute or less;

(g) A minimum operating range extending from 80 to at least 120 dB, or otherwise sufficient to meet the requirements of the measurement; and

(h) For the measurement of impulse noise, an adequately high crest factor capability of at least 10 dB, or otherwise sufficient to meet the requirements of the measurement.

(4) Integrating-Averaging Sound Level Meter - An integrating-averaging sound level meter is an instrument which is capable of operating as a conventional sound level meter with a time-averaging capability such as "slow" and "fast", and which is also capable of integrating the mean square function of the frequency-weighted sound pressure over a period of time. The instrument can provide several types of measurements including the equivalent sound level (L_{eq}) for the period of measurement. Thus an integrating-averaging sound level is effective in the measurement of non-steady noise. Although the instrument gives a time-integrated result, it can be used to give a short-term measurement if it is set to integrate for one minute or less.

Pending the publication of an IEC standard for integrating-averaging sound level meters, the instrument including the microphone must meet the performance requirements of the IEC standard, IEC 651-1979 for the conventional sound level meter. The instrument must also possess a computation circuit which integrates the mean square function of the frequency-weighted sound pressure with respect to time, and provides a value of the equivalent sound level.

For the purposes of this code, the integrating-averaging sound level meter must have the following characteristics:

(a) Type 1 or Type 2 tolerances as specified in IEC 651-1979.

(b) A minimum operating range extending from 80 to 130 dBA (or dBC). For measurements of background sound levels in audiometric sound-proof booths, the operating range must extend to 30 dBA. The operating range is defined as the range between the lower and upper sound levels within which the instrument operates with a linearity of $\pm$ 1 dB.

(c) As appropriate (see section 3(3)(d)), an A- and/or C-weighting frequency characteristic as specified in IEC 651-

1979. An optional frequency weighting characteristic designated as "Lin", "Linear" or "Flat", when provided, can be a substitute for the C-weighting.

(d) A computation circuit capable of integrating the mean square function of the A- or C-weighted sound pressure for a time period of one minute or less at the maximum sound level for a selected level range.

(e) One or more level range settings where any one level range must be at least 30 dB and have an overlap of at least 10 dB between adjacent levels. For any level range setting, the instrument must provide for a suitable overload indication if the measured sound level is outside the range.

(f) For the measurement of impulse noise, an adequately high crest factor capability of at least 10 dB, or otherwise sufficient to meet the requirements of the measurement.

3. Noise Measurement

Noise measurements for the purposes of the noise regulation and associated codes (Hearing Protection; Audiometry) fall into the broad category of Area Noise Measurement. Since noise environments are highly variable and noise measurement not readily standardized, the general measurement procedures for this category, described in section 3(2), must be used in conjunction with the specific procedures, described in section 3(3), for different types of noise, frequency-weighted sound level measurements, and spectral analysis.

The conduct of noise measurements shall be carried out by trained personnel, as specified in the CSA standard Z114-M1977, section D3 "Sound Level Measurement Personnel".

(1) Area Noise Measurement - Area noise measurement is carried out to determine sound levels. The sound levels can be used to determine:-

- the presence of a noise hazard and compliance with the sound level standards specified in the noise regulation;
- the areas where hearing protection equipment must be worn;
- the areas where engineering controls must be implemented;
- the need for a hearing conservation program;
- the selection of appropriate hearing protection equipment, and
- the background sound levels in audiometric sound-proof booths.

Sound level meters may be used in area noise measurement. For the purposes of this code, noise dosimeters and integrating-averaging sound level meters may also be used in area noise measurement provided they are set to integrate for time periods not greater than one minute in duration so as not to give a time-weighted-average result. The measurements consist of sound level data and/or 1 minute L_{eq} data.

(2) General Procedures

(a) Selection of Instruments

The instruments including the microphone must be selected to be appropriate for the type of noise, as outlned in section 3(3), and the environmental conditions, as outlined in section 3(2)(d).

(b) Calibration

The instruments must be calibrated with an acoustic calibrator of known frequency and sound pressure level in

accordance with the manufacturer's instructions before and after each day of use. More frequent calibrations may sometimes be necessary. If the instrument calibration changes by more than ± 1 dB from the previous calibration, the measurements must be rejected.

(c) Battery Check

If the instrument is battery-powered, the condition of the battery must be checked in accordance with the manufacturer's instructions before and after each day of use and ascertained to be within the range recommended by the manufacturer for proper operation.

(d) Environmental Conditions

A number of environmental factors must be considered before and during noise measurement. These are temperature, humidity, wind, vibration, corrosive atmospheres, explosive atmospheres, and magnetic fields. The manufacturer's instructions regarding measurement and environmental conditions must be followed.

(e) Time Segments for Representative Measurements

The work day must be divided into a number of time segments, each defined as a duration in which the noise is of a specific character and can be represented by a single value of sound level. These time segments must reflect the variability of the noise environment in a work day. A time segment may be a fraction of a work day or a full work day.

(f) Instrument Setting

The instrument must be set (frequency weighting characteristic-A, C, or Linear; time weighting characteristic- "slow", "fast", or "impulse") in accordance with the specific procedures described in section 3(3) for different types of noise.

(g) Instrument Configuration

(i) The microphone must be positioned in the hearing zone of the worker within 0.5 metres of the estimated head position.

(ii) The microphone must be positioned not less than 1 metre above the floor and preferably not less than 1 metre from any sound-reflecting surface.

(iii) The microphone of a hand-held instrument must be at arm's length from the body of the investigator, and at a right angle to the straight line passing through the source and the investigator. The body of the investigator must not be between the noise source and the microphone.

(iv) The microphone must be oriented relative to the noise source at the angle of incidence recommended by the manufacturer for flattest frequency response in a free field.

(h) Instructions to the Worker

The purpose of the instrument must be explained and the worker must be instructed to continue to work in a routine manner and not allow the instrument or the investigator to interfere with normal work.

(i) Measurement Locations

Measurements should be taken in the following locations:

(i) Where the sound levels are thought to be high;

(ii) At work stations and other work areas, to obtain a representative record of the noise environment;

(iii) In audiometric sound-proof booths.

(j) Workers to be Monitored

Noise measurements must be carried out for workers who are exposed to the highest sound levels in each job category. Measurements for one worker may be used to represent similarly exposed workers.

(k) Readings at each Measurement Location

(i) Sound level readings must be taken in accordance with the specific procedures described in section 3(3) for different types of noise.

(ii) If the instrument is not equipped with an internal elapsed-time clock, the investigator must determine the period of measurement at a given location by means of a time-measuring device.

(iii) A sound level value obtained as described in section 3(3) from a set of readings in a specific period of measurement and at a given location must be

characteristic and representative of an entire time segment of a work day.

(iv) Readings and the sound level value derived from them must be obtained for every time segment of a work day in which the noise environment is significantly different.

(v) The acoustic characteristics of the environment must not be modified while measurements are being taken.

(3) Specific Procedures

The Canadian Standards Association (CSA) standard Z107.2-1973 "Methods for the Measurement of Sound Pressure Levels" classifies noise as follows:

Steady Noise (with and without audible discrete tones)

Non-Steady Noise (with and without audible discrete tones)

- fluctuating noise,
- intermittent noise,
- impulse noise:
  - isolated impulses,
  - quasi-steady noise.

Although these basic types of noise may not be encountered as isolated cases, every noise environment can generally be assessed in terms of them.

Regardless of the type of noise being investigated, it is good practice to carry out a preliminary walk-through survey before measurements are actually taken in order to assess qualitatively the temporal and spatial character of the noise environment. This preliminary survey will provide information on the type of noise present, and hence on the appropriate measurement techniques and instrumentation to be used. Observations of the noise environment should be made with a Type 1 or Type 2 sound level meter set on the "fast" as well as the "slow" response to identify, for example, the nature of the noise fluctuations or the presence of impulses. The sound level meter, set on either the "fast" or "slow' response, should be moved about in different locations and directions to determine, for example, the areas of highest sound levels, the directionality of the noise field, and the presence of standing waves or interference phenomena.

(a) Steady Noise Measurement

Steady noise is characterized by a relatively constant sound level over a long period of time or during the period of measurement. It may or may not contain audible discrete tones. This type of noise can be determined simply by listening since sound level changes of 1 dB or less cannot be detected while changes of 6 dB or more are quite apparent. Thus, measurements with a sound level meter set on the "slow" response which vary by less than 6 dB may be considered to be measurements of steady noise.

(i) Steady Noise: Using a Sound Level Meter

A Type 2 or better sound level meter which meets the specifications outlined in section 2(1) may be used to measure sound levels of steady noise with

and without audible discrete tones. Sound level readings must be taken with the "slow" response and A- or C-weighting, as appropriate. Any fluctuations in the reading with the instrument operating on the "slow" response must be less than $\pm$ 3 dBA (or dBC) during the entire period of measurement at any one measurement location.

For a specific measurement location and time segment, a minimum of three observations must be made. The observation time for each must be 15 seconds or more. It is advisable that the observations be spaced several minutes apart so that they are representative of sound levels in the entire time segment. For each observation, the average sound level reading, L_{obs}, (approximated by the mean of the maximum and minimum sound level fluctuations during the observation period) must be noted. The arithmetic mean of the average sound level readings, rounded to the nearest decibel, is the datum to be reported, and shall represent the sound level measurement, L_S, for the specific location and time segment.

Steady noise with audible discrete tones may lead to a situation where there are large spatial variations in sound level caused by standing waves or interference phenomena. To ensure that measurements of sound level are valid and not influenced by local interferences, the microphone of the sound level meter should be moved a distance of approximately 1 metre about the measurement position during each observation period.

If the purpose of the sound level measurement is to select a hearing protector and the steady noise has audible discrete tones, a narrow band frequency analysis must be performed, as described in section 3(3)(e).

(ii) Steady Noise: Using a Noise Dosimeter

A noise dosimeter which meets the specifications outlined in section 2(3) may be used to measure sound levels of steady noise with and without audible discrete tones.

For a specific measurement location and time segment, the dosimeter must be set to integrate for one minute or less. The value of the percent daily noise dose obtained for the period of measurement must be converted to an average sound level reading, L_{obs}, for the observation using either the calculation procedure provided by the manufacturer or the appropriate equation as follows:

$$L_{obs} = 90 + 10 \log_{10} \left(\frac{D}{750T}\right) \quad \text{(Equation 3.1)}$$

for a 3dB exchange rate dosimeter, or

$$L_{obs} = 90 + 16.61 \log_{10} \left(\frac{D}{750T}\right) \quad \text{(Equation 3.2)}$$

for a 5dB exchange rate dosimeter,

where T is the duration in minutes and D in % is the percent daily noise dose for the period of measurement. The average sound level reading, L_{obs}, for the observation, rounded to the nearest decibel, is the datum to be reported and shall represent the average sound level measurement, L_S,

for the specific location and time segment. For steady noise, one observation is sufficient but three observations are preferred. With three observations, the average sound level, L_s, for the time segment and location shall be calculated using equation (3.4) on page Mc.17.

For steady noise with audible discrete tones, the precautions regarding standing waves which are specified in section 3(3)(a)(i) must be followed.

(iii) Steady Noise: Using an Integrating-Averaging Sound Level Meter

A Type 2 or better integrating-averaging sound level meter may be used to measure the equivalent sound level (L_{eq}) of steady noise with and without audible discrete tones. Readings must be taken with the A- or C-weighting, as appropriate.

For a specific measurement location and time segment, the instrument must be set to integrate for 1 minute or less. The equivalent sound level (L_{eq}) for the observation, rounded to the nearest decibel, is the datum to be reported, and shall represent the sound level measurement, L_s, for the specific location and time segment. For steady noise, one observation is sufficient but three observations are preferred. With three observations, the L_{eq} value which is to be reported for the time segment and location shall be calculated using equation (3.5) on page Mc.21.

For steady noise with audible discrete tones, the precautions regarding standing waves which are specified in section 3(3)(a)(i) must be followed.

(b) Fluctuating and Intermittent Noise Measurement

Fluctuating noise is characterized by a sound level which varies over a range greater than 6 dB (as measured with the "slow" response of a sound level meter) either continuously and erratically or between two or more well-defined steady levels produced, for example, by the cyclic operation of a machine. An intermittent noise is generally produced by sources which cycle on and off; the sound level deviates momentarily and perhaps repeatedly from the ambient or background level by more than 6dB at regular or irregular intervals for a time period of one second or more. During the "on" cycle, the intermittent noise may exhibit either fluctuating or steady characteristics.

(i) Fluctuating/Intermittent Noise: Using a Sound Level Meter

A Type 2 or better sound level meter which meets the specifications outlined in section 2(1) may generally be used to measure sound levels of fluctuating and intermittent noise. Sound level readings must be taken with the "slow" response and A- or C-weighting, as appropriate.

For fluctuating noise which varies continuously and erratically, a minimum of three observations must be made for a specific measurement location and time segment. The observation time for each

observation shall be 30 seconds or more. The observations must be spaced several minutes apart so that they are representative of sound levels in the entire time segment. For each observation, the maximum and minimum sound level readings during the observation period must be noted. The mean indication of the meter does not correspond to the average sound level reading because of the nature of addition of logarithmic quantities so the average sound level reading must be determined as follows:

- If the total range of meter fluctuation during the observation period is between 6 and 10 dB, the average sound level reading, L_{obs}, for the observation shall be approximated to be 3 dB below the maximum reading. If successive fluctuations are observed to have different maximum levels, the average sound level reading for the observation shall be approximated to be 3 dB below the mean of the maximum levels.

- If the total range of meter fluctuation during the observation period is greater than 10 dB, the average sound level reading for the observation, L_{obs}, shall be obtained from several readings taken at approximately equal time intervals of two seconds or more, using the following equation:

$$L_{obs} = 10 \log_{10} \left[\frac{1}{N} \sum_{i=1}^{N} 10^{0.1 L_i} \right]$$

(Equation 3.3)

where N is the number of readings for the observation, and L_i is the level at each reading. The number of readings should be 10 or more; it is

accepted practice to obtain a number of readings which equals the total range of the noise fluctuations in decibels.

If the difference between any two average sound level readings is greater than 6 dB, a minimum of six observations must be made. The average sound level, L_s, for the period of measurement shall be calculated from the observations as follows:

$$L_s = 10 \log_{10} \sum_{i=1}^{n} \frac{t_i}{T_m} 10^{0.1 L_{obs,i}}$$

(Equation 3.4)

where t_i is the observation time and $L_{obs,i}$ is the average sound level reading for an observation, n is the number of observations, and T_m is the total measurement period which equals the sum of the observation times. The value of L_s, rounded to the nearest decibel, is the datum to be reported, and shall represent the sound level measurement for the specific location and time segment.

For fluctuating noise which varies between two or more well-defined steady values, the sound level at each steady value must be determined and reported, using the method specified in section 3(3)(a) for steady noise. An estimate of the total time intervals for the different steady values must also be obtained, and these shall be considered to be separate time segments.

For intermittent noise, the sound level during the "on" cycle must be determined and reported. The method specified in this section or in section 3(3)(a) must be used, depending on whether the intermittent noise exhibits fluctuating or steady characteristics during the "on" cycle. An estimate of the time intervals for the "on" and "off" cycles must also be obtained, and these shall be considered to be separate time segments.

The use of a Type 2 sound level meter operating on the "slow" response is inadvisable if the fluctuating or intermittent noise has a significant impulse component. The presence of a significant impulse component in the fluctuating or intermittent noise may be deduced from preliminary observations using the "fast" response of the sound level meter. Another test is to compare the readings obtained with the A-weighted "fast" response and the A-weighted "slow" response of a sound level meter. If the difference in these readings is significant (5 to 10 dBA), the fluctuating or intermittent noise might be judged to have a significant impulse component with impulse durations less than 300 milliseconds, and the methods outlined in section 3(3)(c) for impulse noise must be followed.

(ii) Fluctuating/Intermittent Noise: Using a Noise Dosimeter

A noise dosimeter which meets the specifications outlined in section 2(3) may generally be used to measure sound levels of fluctuating and intermittent noise. A dosimeter is more effective than a sound

level meter in area noise measurement of fluctuating and intermittent noise; it is also effective in personal exposure measurement in situations where sound levels vary throughout the time segment either in time, as is the case for fluctuating or intermittent noise, or in location if the worker moves about during the course of his work.

For fluctuating noise which varies continuously and erratically, a minimum of three observations must be made for a specific measurement location and time segment. For each observation, the instrument must be set to integrate for one minute or less. The observations must be spaced several minutes apart so that they are representative of sound levels in the entire time segment. The value of the percent daily noise dose obtained for each observation must be converted to an average sound level reading, L_{obs}, for that observation using either the calculation procedure provided by the manufacturer or the appropriate equations (3.1) or (3.2) on page Mc.13. If the difference between any two average sound level readings is greater than 6 dB, a minimum of six observations must be made. The average sound level, L_S, for the period of measurement shall be calculated using equation (3.4) on page Mc.17. The value of L_S, rounded to the nearest decibel, is the datum to be reported, and shall represent the sound level measurement for the specific location and time segment.

For fluctuating noise which varies between two or more well-defined steady sound levels and for

intermittent noise, the precautions specified in section 3(3)(b)(i) must be followed.

Care must be exercised in a dosimetry measurement if the fluctuating or intermittent noise is suspected to have a significant impulse component, since the noise dosimeter is basically an integrating noise measuring device with a "slow" response. If there is a significant impulse component, the noise dosimeter should be used only if it is specified by the manufacturer for the measurement of impulse noise. The dosimeter must have an adequately high crest factor capability of at least 10 dB, or otherwise sufficient to meet the requirements of the measurement.

(iii) Fluctuating/Intermittent Noise: Using an Integrating-Averaging Sound Level Meter

A Type 2 or better integrating-averaging sound level meter may generally be used to measure the equivalent sound level (L_{eq}) of fluctuating and intermittent noise. In both area and personal exposure measurement of fluctuating and intermittent noise, an integrating-averaging sound level meter is more effective in determining the L_{eq} value than a conventional sound level meter, since the former takes many more readings at frequent intervals and does the averaging automatically, thus yielding a more accurate result. Readings must be taken with the A- or C-weighting, as appropriate.

For fluctuating noise which varies continuously and erratically, a minimum of three observations must

be made for a specific measurement location and time segment. For each observation, the instrument must be set to integrate for one minute or less. The observations must be spaced several minutes apart so that they are representative of sound levels in the entire time segment. If the difference between any two equivalent sound level (L_{eq}) readings is greater than 6 dB, a minimum of six observations must be made. The equivalent sound level (L_{eq}) value for the period of measurement $L_{eq,s}$ must be calculated from the observations as follows:

$$L_{eq,s} = 10 \log_{10} \sum_{i=1}^{n} \frac{t_i}{T_m} \; 10^{0.1 L_{eq,i}}$$

(Equation 3.5)

where t_i is the observation time and $L_{eq,i}$ is the equivalent sound level reading for an observation, n is the number of observations, and T_m is the total measurement period which equals the sum of the observation times. The value of $L_{eq,s}$ rounded to the nearest decibel, is the datum to be reported, and shall represent the sound level measurement, L_s, for the specific location and time segment.

For fluctuating noise which varies between two or more well-defined steady sound levels, and for intermittent noise, the precautions specified in section 3(3)(b)(i) must be followed.

If there is a significant impulse component, the integrating-averaging sound level meter should be used only if it is specified by the manufacturer for

the measurement of impulse noise. The instrument must have an adequately high crest factor capability of at least 10 dB, or otherwise sufficient to meet the requirements of the measurement.

(c) Impulse Noise Measurement

Impulse noise is characterized by brief excursions of sound pressure which significantly exceed the ambient sound pressure. There are two sub-categories of impulse noise:

Isolated Impulses: The noise consists of a single pressure pulse or a single burst (multiple pressure pulses) having a duration less than one second with an interval between pulses or bursts greater than one second.

Quasi-Steady Noise: The noise consists of a train of pulses or bursts with the duration of each pulse or burst being less than one second. The individual pulses or bursts may have equal or unequal amplitudes and/or spacing. The time interval between individual pulses or bursts is one second or less, and prevents their detailed resolution with a sound level meter operating with the "slow" response.

(i) Impulse Noise: Using a Sound Level Meter

Isolated Impulses

The maximum sound level of isolated impulses must be measured with a Type 1 sound level meter which

meets the specifications outlined in section 2(1). Readings must be taken with the "impulse" response.

For a specific measurement location and time segment, a minimum of 10 impulses must be measured. For each impulse, the maximum sound level reading must be determined, and the average of the readings, $L_{I,avg}$, must be calculated as follows:

$$L_{I,avg} = 10 \log_{10} \frac{1}{N} \sum_{i=1}^{N} 10^{0.1 L_{I,i}}$$

(Equation 3.6)

where $L_{I,i}$ is the maximum sound level reading of each impulse and N is the number of impulses. The value of $L_{I,avg}$, rounded to the nearest decibel, is the datum to be reported, and shall represent the impulse sound level measurement for the specific measurement location and time segment.

Quasi-Steady Noise

A Type 1 sound level meter which meets the specifications outlined in section 2(1) may be used to measure the sound levels of quasi-steady noise. The instrument must have an adequately high crest factor capability of at least 10 dB, or otherwise sufficient to meet the requirements of the measurement. Sound level readings must be taken with the "slow" response and A- or C-weighting, as appropriate.

For a specific measurement location and time segment, the measurement procedure outlined in section 3(3)(a)(i) for steady noise must be used if the observed fluctuations in the sound level, with the instrument operating on the "slow" response, are less than $\pm$ 3 dBA (or dBC). If the fluctuations in the sound level are greater than 6 dBA (or dBC), the measurement procedure outlined in section 3(3)(b)(i) must be used. The datum reported shall represent the sound level measurement for the specific location and time segment.

(ii) Impulse Noise: Using a Noise Dosimeter

A noise dosimeter which meets the specifications outlined in section 2(3) may be used only for quasi-steady noise to measure the sound levels provided it is specified by the manufacturer for the measurement of impulse noise. The instrument must have an adequately high crest factor capability of at least 10 dB, or otherwise sufficient to meet the requirements of the measurement.

For a specific measurement location and time segment the measurement procedure outlined in section 3(3)(b)(ii) must be used. Alternatively, the measurement procedure outlined in section 3(3)(a)(ii) for steady noise may also be used if it is verified that the fluctuations in sound level, as measured with the "slow" response of a Type 1 sound level meter, are less than $\pm$ 3 dBA (or dBC). The average sound level, L_S, is the datum to be reported.

(iii) Impulse Noise: Using an Integrating-Averaging Sound Level Meter

A Type 1 integrating-averaging sound level meter may be used only for quasi-steady noise to obtain a measurement of the equivalent sound level (L_{eq}), provided it is specified by the manufacturer for the measurement of impulse noise. The instrument must have an adequately high crest factor capability of at least 10 dB, or otherwise sufficient to meet the requirements of the measurement. Readings must be taken with the A- or C-weighting, as appropriate.

Quasi-Steady Noise

For a specific measurement location and time segment, the measurement procedure outlined in section 3(3)(b)(iii) must be used. Alternatively, the measurement procedure outlined in section 3(3)(a)(iii) for steady noise may also be used if it is verified that the fluctuations in sound level, as measured with the "slow" response of a Type 1 sound level meter, are less than $\pm$ 3 dBA (or dBC). The L_{eq} value reported shall represent the sound level measurement, L_S, for the specific location and time segment.

(d) Weighted Sound Level Measurements

Sound level measurements must be carried out with the A-weighting network to determine:

- the presence of a noise hazard, and compliance with the sound level standards specified in the noise

regulation;

- the areas where hearing protection equipment must be worn;

- the areas where engineering controls must be implemented, and

- the need for a hearing conservation program.

Sound level measurements must be carried out with the "unweighted" or "linear" setting of an instrument to measure the background sound levels in audiometric sound-proof booths, as outlined in the Code for Audiometry of Noise-Exposed Workers.

In selecting an appropriate hearing protector by the procedures outlined in the Code for Hearing Protection of Noise-Exposed Workers, sound level measurements must be carried out with the A-, C-, and/or "linear" weighting networks, depending on the method of selection.

(e) Spectral Analysis

Measurements of the sound levels in octave bands with center frequencies at 250, 500, 1000, 2000, 4000 and 8000 Hz are required in the selection of an appropriate hearing protector as outlined in the Code for Hearing Protection of Noise-Exposed Workers. Measurements of the sound pressure levels in octave bands and/or third-octave bands with center frequencies in the range of 250 to 8000 Hz are required in the assessment of background sound levels in audiometric sound-proof booths, as outlined in the Code for Audiometry of Noise-Exposed Workers.

Octave and third-octave band sound level measurements must be carried out with a Type 2 or better sound level meter or integrating-averaging sound level meter, equipped with the appropriate octave or third-octave band filter set which meets the specifications outlined in section 2(2).

Where required, the overall A- or C-weighted sound level, $L_{overall}$, may be calculated respectively from the A- or C-weighted band noise level measurements (octave or third-octave) as follows:

$$L_{overall} = 10 \log_{10} \sum_{\substack{\text{measured} \\ \text{bands}}} 10^{0.1 L_{B,i}}$$

(Equation 3.7)

where $L_{B,i}$ is the octave or third-octave band noise level measurement.

4. Determination of Compliance

In determining compliance, the measured sound level values in all time segments of a work day must be compared to the sound level standards and action levels specified in the noise regulation.

The noise regulation specifies that a hearing conservation program must be implemented if the sound level to which a worker is or is likely to be subjected to is equal to or greater than 85 dBA for four hours or more in a work day, or is equal to or greater than 90 dBA. Only the sound level data and/or 1 minute L_{eq} data from area noise measurement, obtained as discussed in section 3, are to be used in this calculation.

5. Records

The following information should be included in noise measurements records.

(1) General

(a) As appropriate, the company, plant, department, process, operation, plant section, and work station.

(b) Identity of investigator.

(c) Date and time when measurements were performed.

(2) Noise Environment

(a) Location and description of the relevant noise sources, using a dimensioned sketch if necessary.

(b) Qualitative description of the type of noise.

(c) The time segments.

(d) As appropriate, a description of the physical layout of the relevant work areas, using a dimensioned sketch if necessary (e.g. size and shape of room, location of work stations, locations of barriers and enclosures, types of surface materials, and existing acoustical treatment).

(3) Instrumentation

(a) The instruments used to carry out measurements, including the microphones, filter sets, acoustic calibrators and extension cables or rods identified by name, type, model,

serial number, and manufacturer.

(b) Operational information including calibration and battery check data.

(4) Data for Area Noise Measurement

(a) Measurement details such as instrument setting, instrument configuration, and environmental conditions.

(b) Measurement locations and time segments.

(c) Area noise readings per section 3(2)(k) with durations of measurement, treatment of data, and values of sound levels preferably listed in tabular form and referenced to measurement locations and time segments.

(d) A comparison of sound levels with the standards specified in the noise regulation, and action taken.

THE NOISE MEASUREMENT PROVISIONS USED BY THE MINISTRY OF LABOUR WILL BE REVIEWED PERIODICALLY AND, IF NECESSARY, REVISED.

APPENDIX

Glossary

Crest factor - The ratio of the peak value and the root-mean-square value measured over a specified time interval where both values are measured in reference to the arithmetic mean value of the wave.

Criterion daily duration - A duration of 8 hours which is used as the time basis for measurement by a dosimeter.

Criterion daily noise exposure - The product of the criterion daily duration (8 hours), and the mean-square sound pressure corresponding to the criterion noise level (90 dB).

Criterion sound level - A noise level of 90 dB which is the basis for measurement by a noise dosimeter. It is the steady level in dB at which an 8 hour exposure produces a percent daily noise dose of 100%.

Decibel (dB) - Dimensionless unit of sound level and sound pressure level.

Decibel A-weighted (dB A) - Unit of sound pressure level modified by A-weighting.

Equivalent sound level (L_{eq}) - The A-weighted sound level in dBA of a steady sound which contains the same total acoustic energy integrated over a specified time period as the actual time-varying sound of interest. The time period may be specified in brackets as in the following examples: L_{eq} (1 min.) or L_{eq} (2 hrs.).

Exchange rate - The number of dB increase or decrease which causes the exposure time to be respectively halved or doubled, if the sound exposure is

to remain unchanged. For the noise regulation, the exchange rate is 3 dB.

Percent daily noise dose - The ratio of the noise exposure and the criterion daily noise exposure, expressed in percent.

Noise exposure - The time integral, over a stated time or event, of the "slow", exponential time-averaged, squared, A-weighted, sound pressure signal.

Sound level - The A- or C-weighted sound pressure level.

Sound pressure level - 20 times the logarithm to the base 10 of the ratio of the root mean square (rms) pressure of a sound to the root mean square of the reference pressure using a reference of 20 micropascals.

Threshold level of a dosimeter - The sound level in dB below which the dosimeter produces little or no indication. It is the sound level at which integration begins.

APPENDIX Na

CODE FOR MEDICAL SURVEILLANCE OF NOISE-EXPOSED WORKERS

June 23, 1981

Occupational Health Branch
Ministry of Labour

MEDICAL SURVEILLANCE PROGRAM

1. Purpose

The objective of a medical surveillance program is to protect the health of workers by:

(1) evaluating the hearing of a worker;

(2) assessing a worker's fitness to continue in exposure;

(3) enabling remedial action to be taken in respect of the worker and the environment when necessary;

(4) providing health education.

2. Program

The medical surveillance program must consist of the following:

(1) Pre-employment and pre-placement examinations;

(2) Periodic medical examinations;

(3) Audiometric tests;

(4) Health education;

(5) Record keeping.

3. Medical Examinations

The medical examination and clinical tests conducted by the

physician or under his direction must include the following:

(1) History

The initial medical and occupational history must include enquiry for previous exposure to noise (both occupational and non-occupational) and a history of present or past ear and hearing disorders. At the periodic examination the history must be updated to include:

(a) history of frequency and duration of exposure to noise since previous examination;

(b) enquiry for signs and symptoms that may be an early indication of a hearing impairment or ear defect.

(2) Physical Examination

An otoscopic examination is required.

4. **Audiometric Tests**

An initial audiometric test aids in the assessment of a worker's fitness for work, and in the detection of non-work related ear disease. Periodic tests will permit the detection of any deterioration in hearing, and consideration of the need to modify the type of hearing protection or extent of noise exposure.

Audiometry must be of sufficiently high quality to provide reliable tests results. Guidance on instruments suitable for industrial screening, and their use is given in the Code for Audiometry.

(1) Action Levels

Any significant confirmed deterioration in hearing from previous tests, e.g. 10 dB or more at any one frequency, 5 dB or more average over three adjacent frequencies, must be evaluated by the company physician, the noise exposure reassessed and the worker counselled. If the cause and diagnosis is uncertain, further otological investigation must be sought.

Workers with a noise induced hearing threshold average of 25 dB at 0.5, 1, 2 and 3 kHz in either ear should be referred for Workmen's Compensation Board assessment.

If the worker has sustained a noise induced hearing loss a determination must be made by the physician as to whether the worker is fit with limitations or unfit and action taken in accordance with Section 16 of the Noise Regulation.

5. **Health Education**

All workers must be made aware of the hazard from noise, the precautions to be taken to prevent hearing loss, and the proper care and use of hearing protectors. Quiet rooms provided as hygiene facilities under a hearing conservation program should be used during break periods.

Their examination results must be discussed.

6. **Medical History and Examination Records**

Under the provisions of the noise regulation the examining physician must maintain health records for each worker examined. Such records should include:

- name in full of the worker;

- maiden surname of mother;
- date of birth;
- sex;
- Social Insurance Number;
- the type of noise: continuous, intermittent, impact;
- occupational or job titles of worker;
- date occupations or jobs commenced;
- date occupations or jobs ended;
- the kinds of operations or processes in which the worker is involved;
- noise levels and length of exposure per shift;
- use of hearing protectors;
- dates of visits to physician's office;
- medical examination reports;
- health assessments;
- records of audiometric tests;
- copies of referral letter to a hospital or physician;
- copies of Forms 7 and 8 of Workmen's Compensation Board if completed;
- all relevant information concerning health, and any information concerning the actions taken in response to abnormal audiometric tests.

A worker's health records must be kept in a secure place by the examining physician for:

(1) a period of forty years from the time such records were first made, or

(2) a period of twenty years from the time the last of such records were made,

whichever is the longer.

Where the examining physician or his successor is no longer able or willing to keep the records, the records are to be forwarded to the Chief Physician, Occupational Health Medical Service of the Ministry, who will keep them in a secure place.

APPENDIX Nb

CODE FOR MEDICAL SURVEILLANCE OF NOISE-EXPOSED WORKERS

MINISTRY OF LABOUR
OCCUPATIONAL HEALTH AND SAFETY DIVISION
November 23, 1981

MEDICAL SURVEILLANCE PROGRAM

1. Purpose

The objective of a medical surveillance program is to protect the health of workers by:

(1) ensuring fitness for exposure to noise;

(2) evaluating the effect of noise on workers;

(3) enabling remedial action to be taken when necessary; and

(4) providing health education.

2. Program

The medical surveillance program must consist of the following:

(1) pre-placement examinations;

(2) periodic examinations;

(3) audiometric tests;

(4) health education; and

(5) record keeping.

3. Medical Examinations and Clinical Tests

The frequency of the medical examinations and clinical tests will depend on the intensity and length of exposure to noise, and should be decided by the examining physician.

The medical examinations and clinical tests conducted by the physician or under his direction must include the following:

(1) History

The initial medical and occupational histories must include enquiry for previous exposure to noise (both occupational and non-occupational) and a history of present or past ear and hearing disorders. Periodically the history must be updated to include:

(a) history of frequency and duration of exposure to noise since previous audiometric test; and

(b) enquiry for signs and symptoms that may be an early indication of a hearing impairment or ear defect.

(2) Physical Examination

An initial otoscopic examination is required to identify pathology when the audiometric test reveals a hearing threshold level below that considered to be normal for the age of the worker, or when there has been a significant deterioration in hearing from the baseline and subsequently at the discretion of the physician.

(3) Clinical Tests

(a) Audiometry

Audiometric tests must be undertaken in facilities that meet the requirements of the Code for Audiometry of Noise-Exposed Workers.

An initial audiometric test aids in the assessment of the fitness of a worker for work in noise, and in the detection of non-work related ear diseases. Periodic tests will permit the detection of any deterioration in hearing, and consideration of the need to modify the type of hearing protection or extent of noise exposure. The tests must be carried out at least on a biennial basis, or more often when an employee shows a significant change in hearing level.

(b) Action Levels

Any confirmed significant threshold shift from the baseline or more recent audiogram in either ear must be reviewed by the examining physician, the noise exposure and hearing protection reassessed and the worker counselled. If the cause and diagnosis is uncertain, further otological investigation must be sought.

Workers with a confirmed hearing loss of 25 dB average at 0.5, 1, 2 and 3 kHz in both ears should be referred for Workmen's Compensation Board assessment, if the hearing loss is thought to be occupationally induced. A determination must be made by the physician as to whether the worker is fit with limitations or unfit and action taken in accordance with Section 16 of the Noise Regulation.

(c) Reporting

The audiograms must be read by the physician, or an audiologist or audiometric technician working under his direction. The physician should provide the joint health

and safety committee with an annual report, summarizing the results of audiometric tests.

4. Health Education

All workers must be made aware of the hazard from noise, the precautions to be taken to prevent hearing loss, and the proper care and use of hearing protectors. During break periods, workers must be encouraged to use quiet rooms (less than 80 dBA) provided as hygiene facilities under a hearing conservation program.

The results of the examinations and clinical tests must be discussed with the worker to provide explanation and reassurance as necessary.

5. Medical History and Examination Records

Under the provisions of the Noise Regulation the examining physician must maintain health records for each worker examined. Such records should include:

- name in full of the worker;
- maiden surname of mother;
- date of birth;
- sex;
- Social Insurance Number;
- the type of noise: continuous, intermittent, impact;
- occupational or job titles of worker;
- date occupations or jobs commenced;
- date occupations or jobs ended;
- the kinds of operations or processes in which the worker is involved;
- noise levels and length of exposure per shift;
- use of hearing protectors;
- dates of visits to physician's office;

- medical examination reports;
- health assessments;
- records of audiometric tests;
- copies of referral letter to a hospital or physician;
- copies of Forms 7 and 8 of Workmen's Compensation Board, if completed;
- all relevant information concerning health, and any information concerning the actions taken in response to abnormal audiometric tests.

A worker's health records must be kept in a secure place by the examining physician for:

(1) a period of forty years from the time such records were first made, or

(2) a period of twenty years from the time the last of such records were made,

whichever is the longer.

Where the examining physician or his successor is no longer able or willing to keep the records, the records are to be forwarded to the Chief Physician, Occupational Health Medical Service of the Ministry, who will keep them in a secure place.

APPENDIX Nc

CODE FOR MEDICAL SURVEILLANCE OF NOISE-EXPOSED WORKERS

MINISTRY OF LABOUR
OCCUPATIONAL HEALTH AND SAFETY DIVISION
November 5, 1982

1245112382

MEDICAL SURVEILLANCE PROGRAM

1. Purpose

The objective of a medical surveillance program is to protect the health of workers by:

(1) ensuring fitness for exposure to noise;

(2) evaluating the effect of noise on workers;

(3) enabling remedial action to be taken when necessary; and

(4) providing health education.

2. Program

The medical surveillance program must consist of the following:

(1) pre-placement examinations;

(2) periodic examinations;

(3) audiometric tests;

(4) health education; and

(5) record keeping.

3. Medical Examinations and Clinical Tests

The frequency of the medical examinations and clinical tests will depend on the intensity and length of exposure to noise, and should be

decided by the examining physician.

The medical examinations and clinical tests conducted by the physician or under his direction must include the following:

(1) History

The initial medical and occupational histories must include enquiry for previous exposure to noise (both occupational and non-occupational) and a history of present or past ear and hearing disorders. Periodically the history must be updated to include:

(a) history of frequency and duration of exposure to noise since previous audiometric test; and

(b) enquiry for signs and symptoms that may be an early indication of a hearing impairment or ear defect.

(2) Physical Examination

An initial otoscopic examination is required to identify pathology when the audiometric test reveals a hearing threshold level below that considered to be normal for the age of the worker, or when there has been a significant deterioration in hearing from the baseline and subsequently at the discretion of the physician.

(3) Clinical Tests

(a) Audiometry

Audiometric tests must be undertaken in facilities that meet the requirements of the Code for Audiometry of

Noise-Exposed Workers.

An initial audiometric test aids in the assessment of the fitness of a worker for work in noise, and in the detection of non-work related ear diseases. Periodic tests will permit the detection of any deterioration in hearing, and consideration of the need to modify the type of hearing protection or extent of noise exposure. The tests must be carried out at least on a biennial basis, or more often when an employee shows a significant change in hearing level.

(b) Action Levels

Any confirmed significant threshold shift from the baseline or more recent audiogram in either ear must be reviewed by the examining physician, the noise exposure and hearing protection reassessed and the worker counselled. If the cause and diagnosis is uncertain, further otological investigation must be sought.

Workers with a confirmed hearing loss of 25 dB average at 0.5, 1, 2 and 3 kHz in both ears should be referred for Workmen's Compensation Board assessment, if the hearing loss is thought to be occupationally induced. A determination must be made by the physician as to whether the worker is fit with limitations or unfit and action taken in accordance with section 20 of the Noise Regulation.

(c) Reporting

The audiograms must be read by the physician, or an audiologist or audiometric technician working under his

direction. The physician should provide the joint health and safety committee with an annual report, summarizing the results of audiometric tests.

4. Health Education

All workers must be made aware of the hazard from noise, the precautions to be taken to prevent hearing loss, and the proper care and use of hearing protectors. During break periods, workers must be encouraged to use quiet rooms (less than 80 dBA) provided as hygiene facilities under a hearing conservation program.

The results of the examinations and clinical tests must be discussed with the worker to provide explanation and reassurance as necessary.

5. Medical History and Examination Records

Under the provisions of the Noise Regulation the examining physician must maintain health records for each worker examined. Such records should include:

- name in full of the worker;
- maiden surname of mother;
- date of birth;
- sex;
- Social Insurance Number;
- the type of noise: continuous, intermittent, impact;
- occupational or job titles of worker;
- date occupations or jobs commenced;
- date occupations or jobs ended;
- the kinds of operations or processes in which the worker is involved;
- noise levels and length of exposure per shift;
- use of hearing protectors;

- dates of visits to physician's office;
- medical examination reports;
- health assessments;
- records of audiometric tests;
- copies of referral letter to a hospital or physician;
- copies of Forms 7 and 8 of Workmen's Compensation Board, if completed;
- all relevant information concerning health, and any information concerning the actions taken in response to abnormal audiometric tests.

A worker's health records must be kept in a secure place by the examining physician for:

(1) a period of forty years from the time such records were first made, or

(2) a period of twenty years from the time the last of such records were made,

whichever is the longer.

Where the examining physician or his successor is no longer able or willing to keep the records, the records are to be forwarded to the Chief Physician, Occupational Health Medical Service of the Ministry, who will keep them in a secure place.

APPENDIX O

PROPOSED REGULATION UNDER THE OCCUPATIONAL HEALTH AND SAFETY ACT

NOISE - DESIGNATED SUBSTANCE REGULATION FOR CONSTRUCTION PROJECTS AND HIGHWAY VEHICLES

MINISTRY OF LABOUR
OCCUPATIONAL HEALTH AND SAFETY DIVISION

February 16, 1982

Noise – Designated Substance*

1. This Regulation applies to,

   (a) a constructor, an employer who is carrying out a project and a worker working on or at a project; and

   (b) an employer of a worker working in or on a vehicle on a highway and such a worker.

* NOTE Noise was designated in the Noise Regulation O. Reg. ____
The definitions contained in the Noise Regulation apply throughout this Regulation and are reproduced below for ease of reference:

   (a) "A-weighting" means A-weighting as defined by the International Electrotechnical Commission (IEC) Standard 651-79;

   (b) "decibel" ("dB") means a dimensionless unit of sound pressure level or sound level;

   (c) "decibel A-weighted" ("dBA") means a unit of sound pressure level modified by A-weighting";

   (d) "highway" means a highway as defined in the Highway Traffic Act;

   (e) "impulse noise" and "impact noise" mean an impulsive sound caused by collision of solids or sudden pressure change in gases, either as a single pressure pulse or a single burst (multiple pressure pulses) having a duration less than one second with an interval between pulses greater than one second;

(f) "joint health and safety committee" means a joint health and safety committee established under section 8 of the Act, a committee of like nature and the workers or their representatives who participate in an arrangement, program or system conforming to subsection 8(2) of the Act;

(g) "noise" means a sound with an A-weighted sound pressure level equal to or greater than 80 dBA;

(h) "sound level" means the A-weighted sound pressure level;

(i) "sound pressure level" ("L_p") means 20 times the logarithm to the base 10 of the ratio of the root mean square ("rms") pressure of a sound to the root mean square of the reference pressure of 20 micropascals.

(j) "vehicle" means a vehicle as defined in the Highway Traffic Act.

2. (1) Every employer on a project shall ensure that every worker required by the employer to work in proximity to equipment which emits sound levels of 90 dBA or greater, and in the case of impulse or impact noise 120 dB or greater, is provided with and uses hearing protection equipment.

(2) Every employer shall ensure that every worker in or on vehicle on a highway which emits sound levels of 80 dBA or greater, determined pursuant to clause 4(1)(b), is provided with and uses, while the vehicle is in operation, hearing protection equipment.

(3) Every employer shall implement engineering controls when they become technologically and economically feasible to reduce the sound

levels emitted by equipment and vehicles until the levels are below the levels at which subsections (1) and (2) require the use of hearing protection equipment.

(4) Every worker shall use the hearing protection equipment required to be provided in subsections (1) and (2) and shall work in accordance with the provisions of the hearing conservation program.

3. (1) Where hearing protection equipment is provided by an employer and used by a worker, the hearing protection equipment shall be appropriate in the circumstances for the type and the levels of noise to which a worker is exposed, and shall meet the requirements set out in the Code for Hearing Protection of Noise Exposed Workers: Construction Projects and Highway Vehicles, dated _____ and issued by the Ministry.

(2) The employer shall provide training and instruction to a worker in the proper care and use of hearing protection equipment and in the health effects of exposure to noise.

4. (1) Every employer shall determine and keep a written record,

(a) of the sound levels arising from the operation of equipment on a project to which a worker on the project may be exposed; and

(b) of the vehicle interior sound levels which will be reached during a static test conducted in accordance with clauses (a) to (k) of subsection 1106(2) of Schedule V of the Motor Vehicle Safety Regulations, C.R.C., c.1038, as amended by S.O.R./79-115.*

* NOTE: The text of subsection 1106(2) of Schedule V of the Motor Vehicle Safety Regulations is reproduced in Appendix A for ease of reference.

(2) The written record made by the employer shall be given by the employer to each member of the joint health and safety committee or the health and safety representative, if any.

5. (1) Where a worker at or on a project may be exposed to noise in excess of 85 dBA, the employer shall put into effect and maintain a hearing conservation program.

(2) Where the results of the static test conducted pursuant to clause 4(1)(b) disclose that a vehicle emits sound levels of 80 dBA or greater, the employer shall put into effect and maintain a hearing conservation program.

(3) The hearing conservation program shall include provisons for:

(a) engineering controls and hearing protection equipment to control the exposure of a worker to noise;

(b) an indication on equipment and vehicles that hearing protection equipment must be worn during operation where such protection is prescribed;

(c) medical examinations and audiometric tests of a worker; and,

(d) records of medical examinations and audiometric tests of a worker to be maintained by the physician who has examined the worker or under whose direction the audiometric tests have been performed.

(4) In developing the hearing conservation program, the employer shall consult with the joint health and safety committee or the health and safety representative, if any, and the committee or representative may make recommendations with respect to the same.

6. Where a change occurs in equipment or vehicles which could result in a significant difference in the sound levels being emitted by the equipment or vehicle and, in any event, at least every two years, the employer shall cause a further determination of the sound levels to be made forthwith and the provisions of sections 4 and 5 shall apply to the further determination.

7. (1) Where disputes arise between an employer and a joint health and safety committee or a health and safety representative, if any, as to the determination required under section 4 or 6 or as to the hearing conservation program or its provisions required under section 5 or 6, the employer, a member of the joint health and safety committee, the committee or a health and safety representative may notify an inspector thereof who shall investigate and give a decision in writing to the employer, the member, the committee or the representative.

(2) Nothing in subsection (1) applies so as to affect the power of an inspector to issue an order for a contravention of this Regulation.

8. (1) A copy of the hearing conservation program put into effect by the employer shall be given by the employer to each member of the joint health and safety committee or the health and safety representative if any and the employer shall acquaint every worker affected by the hearing conservation program with its provisions.

(2) A copy of the hearing conservation program put into effect by the employer shall be made available by the employer in English and in the majority language of the workplace.

9. The procedures for the determination of sound levels in a workplace shall be those set out in the Code for Noise Measurement for Construction Projects and Highway Vehicles, dated _____, and issued by the Ministry.

10. (1) Subject to subsection 2, a worker shall not be permitted to work in a workplace where hearing protection equipment is required to be used by the worker unless the worker undergoes, at the expense of the employer, an audiometric test and a medical examination where such an examination is required by the Code for Medical Surveillance of Noise-Exposed Workers: Construction Projects and Highway Vehicles, dated _____ and issued by the Ministry.

(2) Subsection 1 does not apply to a worker who has undergone, within the last three years, an audiometric test and medical examination as required in subsection 3.

(3) A worker who is required to use hearing protection equipment shall undergo every three years, at the expense of the employer, an audiometric test and a medical examination where such an examination is required by the Code for Medical Surveillance of Noise-Exposed Workers: Construction Projects and Highway Vehicles referred to in subsection (1).

(4) The medical examinations and audiometric tests shall meet the provisions of the Code for Medical Surveillance of Noise-Exposed Workers: Construction Projects and Highway Vehicles referred to in subsection (1).

(5) The audiometric tests of a worker shall be determined in accordance with the Code for Audiometry of Noise-Exposed Workers dated the day of and issued by the Ministry.

11. (1) The records of medical examinations and audiometric tests of a worker obtained and made under this Regulation shall be kept in a secure place by the physician who has conducted the examinations and tests or under whose supervision the examinations and tests have been made for,

(a) a period of forty years from the time such records were first made, or

(b) a period of twenty years from the time the last of such records were made,

whichever is the longer.

(2) Where the physician is no longer able or willing to keep the records, the records shall be forwarded to the Chief Physician, Occupational Health Medical Service of the Ministry, or a physician designated by the Chief Physician and the provisions of subsection (1) shall, with necessary modifications, apply thereto.

12. (1) The physician conducting the medical examination or audiometric tests or under whose supervision the examination or tests are made shall advise the employer, who shall act thereon, and the worker whether the worker is fit, or because of a condition resulting from exposure to noise is fit with limitations or unfit for work in noise without giving or disclosing to the employer the records or results of the examination or tests, and in advising that the worker is fit with limitations or unfit, the physician shall be governed by the provisions of the Code for Medical Surveillance of Noise-Exposed Workers: Construction Projects and Highway Vehicles, referred to in section 10.

(2) Where a worker is removed from exposure to noise because a medical examination or audiometric test discloses that the worker may have or has a condition resulting from exposure to noise and suffers loss of earnings occasioned thereby, the worker is entitled to compensation for the loss in the manner and to the extent provided by the Workmen's Compensation Act.

(3) Upon advising the employer and the worker that a worker is fit, or because of a condition resulting from exposure to noise is fit with limitations or unfit for work in noise, the physician shall advise in writing upon a confidential basis the joint health and safety committee thereof and in giving such advice shall indicate his opinion as to the interpretation to

be placed thereon.

(4) Copies of the records and results of medical examinations and audiometric tests of a worker shall be given by the physician conducting the examination or tests, or under whose supervision the examination or tests are made.

(a) to the worker or his physician upon the request in writing of the worker; and

(b) in the case of a deceased worker, to the next of kin or personal representative of the worker, upon the request in writing of such next of kin or personal representative,

and any authorization of another person by the worker, his next of kin or personal representative is of no effect.

13. For the purposes of this Regulation the methods and procedures that may be used or adopted may vary from the Codes issued by the Ministry if the protection afforded thereby or the factors of accuracy and precision used or adopted are equal to or exceed the protection or the factors of accuracy and precision in the Codes issued by the Ministry.

14. This Regulation, comes into force on the day this Regulation is filed with the Registrar of Regulations.

APPENDIX A

The following is the text of clauses (a) to (k) of subsection 1106(2) of Schedule V of the Motor Vehicle Safety Regulations:

" (a) the vehicle is located so that no other vehicle or signboard, building, hill or other large reflecting surface is within 15.2 m (50 feet) of the driver's seating position;

(b) all vehicle doors, windows and ventilators are closed;

(c) all power-operated accessories are turned off;

(d) the driver is in his normal seated driving position and the person conducting the test is the only other person in the vehicle;

(e) a sound level meter is used that is set at the A-weighting "fast" meter response and meets the requirements of

(i) the American National Standards Institute, Standard ANSI S1.4-1971, "Specification for Sound Level Meters", for Type 1 Meters; or

(ii) the International Electrotechnical Commission (IEC), Publication No. 179 (1973), "Precision Sound Level Meters";

(f) the microphone is located so that it points vertically upward, 150 mm (6 inches) to the right and directly in line with and on the same plane as the driver's ear;

(g) if the motor vehicle's engine radiator fan drive is equipped with a clutch or similar device that automatically either reduces the rotational speed of the fan or completely disengages the fan from

its power source in response to reduce engine cooling loads, the vehicle may be parked before testing with its engine running at high idle or any other speed the operator chooses for sufficient time, but not more than 10 minutes, to permit the engine radiator fan to automatically disengage;

(h) with the vehicle's transmission in neutral gear, the engine is accelerated to

(i) its maximum governed engine speed, if it is equipped with an engine governor, or

(ii) its speed at its maximum rated horsepower, if it is not equipped with an engine governor, and the engine is stabilized at that speed;

(i) the A-weighted sound level reading on the sound level meter for the stabilized engine speed condition referred to in subparagraph (h)(i) or (ii) is observed and, if it has not been influenced by extraneous noise sources, is recorded;

(j) the vehicle's engine speed is returned to idle and the procedures set out in paragraphs (h) and (i) are repeated until two maximum sound levels within 2 dBA of each other are recorded, the two maximum sound level readings are then averaged; and

(k) the average obtained in accordance with paragraph (j), with a value of 2 dBA subtracted therefrom to allow for variations in test conditions and in the capabilities of meters, is the vehicle's interior sound level at the driver's seating position for the purposes of determining compliance with the requirements of this subsection."

APPENDIX P

ORGANIZATIONS THAT
RESPONDED TO THE PUBLICATION OF THE
PROPOSED REGULATION,
JUNE 24, 1981

ORGANIZATIONS* THAT RESPONDED TO THE PUBLICATION OF THE PROPOSED REGULATION, JUNE 24, 1981

ABC Plastic Moulding
20 Brydon Drive
Rexdale, Ontario
M9W 5R6

Algoma Steel Corporation Limited
Sault Ste. Marie, Ontario
P6A 5P2

Allied Chemical Canada Limited
1015 University Avenue West
Windsor, Ontario
N9A 5S6

American Industrial Hygiene Association
Ontario Local Section
P.O. Box 1232, Station 'Q'
Toronto, Ontario
M4T 2P4

Audiosonics Ltd.
24 The East Mall, #6
Toronto, Ontario
M8W 4W5

BASF Canada Inc.
501 Wallrich Avenue
Cornwall, Ontario
K6J 2B5

BP Canada
240 Duncan Mill Road
Don Mills, Ontario
M3B 2B2

Boise Cascade Canada Limited
1455 Idylwild Drive
Fort Francis, Ontario
P9A 3M3

Canadian Acoustical Association
P.O. Box 3651, Station "C"
Ottawa, Ontario
K1Y 4J7

Canadian Battery Manufacturers' Association
One Yonge Street
Toronto, Ontario
M5E 1J9

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* A number of organizations submitted more than one brief.

Canadian Chemical Producers' Association
350 Sparks Street
Suite 805
Ottawa, Ontario
K1R 7S8

Canadian Diamond Drilling Association
c/o Bradley Bros. Limited
P.O. Box 485
Timmins, Ontario
P4N 7E7

The Canadian Hearing Society
60 Bedford Road
Toronto, Ontario
M5R 2K2

Canadian Standards Association
178 Rexdale Boulevard
Rexdale, Ontario
M9W 1R3

Chrysler Canada Ltd.
Chrysler Centre
Windsor, Ontario
N9A 4H6

Cliffs of Canada Limited
P.O. Box 877
Kirkland Lake, Ontario
P2N 3K7

John Deere Welland Works
Welland, Ontario
L3B 3N3

Dofasco
P.O. Box 460
Hamilton, Ontario
L8N 3J5

Dow Chemical of Canada Limited
South Vidal Street
P.O. Box 3030
Sarnia, Ontario
N7T 7M1

Du Pont Canada Inc.
P.O. Box 5000
Kingston, Ontario
K7L 5A5

Emco Limited
P.O. Box 5300
London, Ontario
N6A 4N7

Ford Motor Company
The Canadian Road
Oakville, Ontario

General Motors of Canada Limited
215 William Street East
Oshawa, Ontario
L1G 1K7

B.F. Goodrich Canada Limited
Executive Offices
Kitchener, Ontario
N2G 4J5

Gulf Canada Limited
Box 460, Station 'A'
Toronto, Ontario
M5W 1E5

Hatch Associates Limited
21 St. Clair Avenue East
Toronto, Ontario
M4T 1L9

Hearing Measurements Company Limited
Finchgate Medical Centre
40 Finchgate Boulevard
Bramalea, Ontario
L6T 3J1

IMC Chemical Group (Canada) INc.
Industrial Minerals Divsion
P.O. Box 280
Havelock, Ontario
K0L 1Z0

Inco Metal Company
Copper Cliff, Ontario
P0M 1N0

Industrial Accident Prevention Association
2 Bloor Street East
Toronto, Ontario
M4W 3C2

Industrial Audiometry Services Limited
92 Rutherford Road North
Brampton, Ontario
L6V 2J2

Kelsey-Hayes Canada Limited
Woodstock Division
P.O. Box 300
Woodstock, Ontario

Floyd Laughren, MPP
Room 410, North Wing
Main Legislative Building
Queen's Park
Toronto, Ontario
M7A 1A2

Lear Siegler Industries Limited
General Seating Division
P.O. Box 758
530 Manitou Drive
Kitchener, Ontario
N2G 4C2

K. C. Norton, Minister
Ministry of the Environment
135 St. Clair Avenue West
Toronto, Ontario
M4V 1P5

Ministry of Transportation and Communications
Occupational Health and Safety Office
3rd Floor, West Tower
1201 Wilson Avenue
Downsview, Ontario
M3M 1J8

Mount Sinai Hospital
Department of Otolaryngology
600 University Avneue
Toronto, Ontario
M5G 1X5

Ontario Hydro
700 University Avenue
Toronto, Ontario
M5G 1X6

Ontario Paper Company Limited
P.O. Box 1040
Allanburg Road
Thorold, Ontario
L2V 3Z5

Ontario Speech and Hearing Association
170 St. George Street
Suite 504
Toronto, Ontario
M5R 2M8

Ontario Trucking Association
555 Dixon Road
Rexdale, Ontario
M9W 1H8

Petrosar Limited
785 Hill Street
P.O. Box 7000
Corunna, Ontario
N0N 1G0

Polysar Limited
Sarnia, Ontario
N7T 7M2

Queen's University
Occupational Health Resource Centre
25 Union Street
Kingston, Ontario
K7L 2N6

Ms. R. Rossman
Audiologist
2075 Bayview Avenue
Toronto, Ontario

Society of the Plastics Industry of Canada
1262 Don Mills Road
Suite 104
Don Mills, Ontario
M3B 2W7

Standard Tube Canada Limited
P.O. Box 430
Woodstock, Ontario
N4S 7Y6

Stelco Inc.
General Office
Stelco Tower
Hamilton, Ontario
L8N 3T1

Sudbury Mine, Mill & Smelter Workers Union
Local #598
19 Regent Street South
Sudbury, Ontario
P3C 4B7

Windsor Machine & Stamping Ltd.
777 Caron Avenue
Windsor 12
Ontario
N9A 5B8

Workmen's Compensation Board
2 Bloor Street East
Toronto, Ontario
M4W 3C3

ON LOAN FROM:

Workers' Compensation
Appeals Tribunal
Library

Please return
within
three weeks.

Please write the
date on which you are
borrowing this material
on the space below:

_____
_____
_____
_____

KF 3813 .057 1982 v.3 WCAT
The Report on the
designation of noise in On